DETROIT SCIENTIFIC ASSOCIATION.

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

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ART. XVIII.—*On some Phenomena of Binocular Vision;* by JOSEPH LECONTE, Professor of Geol. and Nat. Hist., University of California.*

## VII. *Position of the eyes in sleepiness.*

IT is usually taught, and I think universally believed by physiologists, that in sleep and also in extreme drowsiness, when control over the ocular muscles is lost, the optic axes turn upward and *inward*. Müller says:† "During sleep the eyes have a peculiar position. At that time, as well as in a *state of mere sleepiness*, both eyes are turned *inward* and upward." I find similar statements by other writers on this subject; but I cannot find any experiments or observations upon which this conclusion is based. I think it probable that it has been reached indirectly thus: It is known that in a state of sleepiness the images of objects double. This double vision may arise either from convergence on divergence of the optic axes. It is very naturally attributed to the former, because in sleep the iris is contracted, and contraction of the irides is usually consensual with convergence of the optic axes. Thus Müller says (p. 535): "The contracted state of the irides in sleep is *a consensual motion dependent on the position of the eyes*, which are turned upward and inward by the inferior oblique muscles." The experiments I am about to describe, however, prove conclusively that, if not in sleep, at least *in sleepiness* or the act of falling to sleep, *the optic axes diverge.*

* For preceding articles on this subject, see this Jour., Ser. II, vol. xlvii, pp. 68 and 153; and Ser. III, vol. i, p. 33, vol. ii, p. 1, vol. ii, pp. 315 and 417.

† Müller's Physiology, Baly's Translation, Am. ed., p. 810.

There are few persons, I suppose, who have not experienced an unconquerable drowsiness while listening to a dull speaker on a warm summer afternoon. Every one at such times must have observed that as the control over the ocular muscles is lost, the head of the speaker, whom he is vainly attempting to regard with attention, becomes double; the two heads separating more and more, until, at the distance of 30 feet, they may seem 10 to 15 feet apart. In my own case the control over the eyes is lost even while the consciousness is perfect, and the mind in a condition to make a scientific experiment. Often, although, by an effort, the control over the eyes could be retained, I have chosen to abandon it, in order to make the experiments related below.

In accordance with the usual doctrine, I had long supposed that this doubling of images in sleepiness was due to optic convergence. On testing it, however, I found I was mistaken. I tested it as follows:

It is well known that the images of all objects nearer or farther off than the point of optic convergence (point of sight) are double. But there is this difference in the two cases: if the object be beyond the point of sight, i. e. if the optic convergence be *too great*, the images *are homonymous*; but if the object be nearer than the point of sight, i. e., if the optic convergence be *too small* (and *a fortiori, if there be optic divergence*) *the images are heteronymous.* Now I have found it perfectly easy, even in the state of drowsiness already mentioned, to perform an experiment to test the position of the optic axes. As soon as the head of the speaker doubles and the two images are well separated, I wink the *right* eye. Invariably the *left* image disappears. The images are therefore heteronymous, and *heteronymous images in this case prove optic divergence.* For even with the point of sight at infinite distance, i. e., the optic axes parallel, the doubling of an object at the distance of 30 or 40 feet would be almost imperceptible (the distance between the centers of the two images being only equal to the interocular distance, or $2\frac{1}{2}$ inches), while in the experiments the images were widely separated, in some cases 10 to 15 feet, indicating therefore an optic divergence of 15° to 20°.

I am sure, in the course of 15 or 20 years I have performed this experiment many hundred times, and always with the same result. But thinking it possible that my own case might be exceptional, I asked Professor E. P. Alexander, one of my colleagues in the University of South Carolina, who had been troubled with similar drowsiness, to make the same experiments. He did so, and his results were identical with my own.

In every case, of course, the experiment rouses the mind and quickly re-unites the images, but not so quickly but that the

result is perfectly obvious. But lest some may regard this speedy re-union of the images as an objection to the reliableness of this mode of experimenting, I devised another method, which is not open to this objection.

While gazing on vacancy, objects near at hand are very perceptibly double, the images being heteronymous. Now if while thus gazing, perhaps in profound thought, the observer should happen to be overcome with drowsiness and lose control over the eyes, *the already heteronymous images will separate more and more widely.* I have made this experiment many times while lying abed in the morning and always with the same result. But this result is impossible except by optic *divergence*, for by convergence the images would approach each other, unite and then cross over and become homonymous.

Thus, then, it is certain, that *in the act of falling to sleep the eyes diverge.* Whether this position is retained in profound sleep, I have tried in vain to determine. The attempt to make observations on the eyes of sleepers, for this purpose, invariably introduces disturbing influences which vitiate the result. I have also attempted observations on sick infants, who often, in a weak condition, drowse with the eyes half open; but I have always found, under these circumstances, the action of the ocular muscles irregular and the position of the optic axes, therefore, unsteady. Nevertheless it seems highly probable that in profound sleep, also, the position of the optic axes is divergent.

I will now bring forward several facts which point to the conclusion reached by these experiments, viz: that the *optic axes diverge when completely relaxed.*

1. Double vision is a well-known phenomenon of the state of drunkenness. Accompanying the double vision there is always observable an unnatural appearance of the eyes, resulting from a want of the perfect parallelism or the very slight convergence of the optic axes, which is a necessary condition of single vision. Double vision may result from too much convergence (squinting) or from divergence; but I think every one who has observed persons in this state will agree with me that the eyes do not squint but *diverge* as in sleepiness, and from the same cause, viz: a loss of control and consequent relaxation of the normal tonic contraction of the muscles of the eyes.

2. The axes of the conical eye-sockets, if produced, would meet each other about the occiput. This gives a divergence, in passing forward, of about 25°. It is probable that in a state of absolutely perfect relaxation, the optic axes coincide with the axes of the eye-sockets, and it requires, therefore, some contraction to bring the optic axes to a condition of parallelism and still more to a condition of convergence, as in every volun-

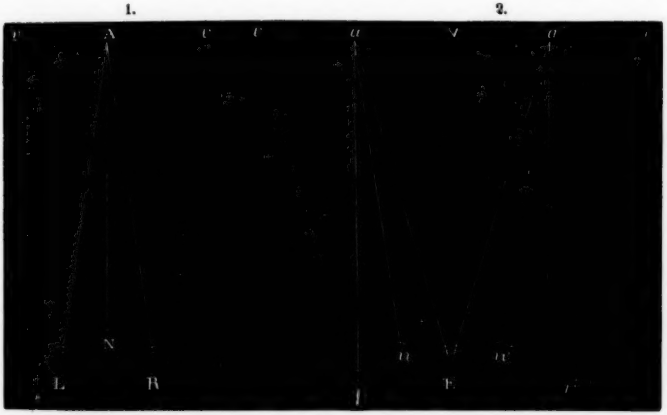
tary act of sight. In the human eye, therefore, and also in that of the highest animals, there are three conditions of the optic axes: 1st, convergence, when we look at a near object; 2d, parallelism, when we look at a distant object or gaze on vacancy; 3d, divergence, when we lose control of the eyes, as in sleep, in drunkenness and probably in death. The 1st requires a distinct voluntary effort—a distinct voluntary contraction of the ocular muscles; in the 2d there is no *voluntary* contraction, but only that tonic contraction characteristic of the waking state; in the 3d the relaxation is complete. The 1st is the *active* state of the eye; the 2d the *waking* passive state; the 3d the *absolutely* passive state.

3. In most normal eyes, in the waking passive state, the optic axes are perfectly parallel, and it is impossible to carry the relaxation so far as to produce divergence. Hence it is easy to double a near object either by looking at a *nearer* or at a *more distant* point—either by *too great* or too small convergence; but it is impossible to double an infinitely distant object, like a star, except in one way, viz: by convergence—by crossing the eyes. For the same reason it is impossible for most normal eyes, *without the use of instruments*, to combine stereoscopically two similar objects or two similar pictures, *beyond the plane of the object or the pictures*, unless the distance between identical points of the objects or pictures be, at most, not greater than the interocular distance. Yet I have known, at least, one man, a gentleman of rare intelligence and much interested in binocular experiments, and whose eyes were to all appearance perfectly normal, in whom the waking passive state, as in gazing on vacancy, was one of slight optic *divergence* —in whom therefore the relaxation was more complete than in most eyes. This gentleman could double a star by gazing vacantly, and as it were beyond it. I thought at first that the doubling was the result of optic convergence, but by placing a screen alternately before the one and the other eye and asking which image disappeared, I completely satisfied myself that his eyes, while gazing on vacancy, were really slightly divergent instead of parallel.

I proved this, however, still more satisfactorily in another way. I have stated that it is impossible for most persons of normal eyes to combine two similar pictures *with the naked eyes*, so as to form a stereoscopic image *beyond the plane of the pictures*, unless the distance between identical points in the pictures be, at most, not greater than the interocular distance. But this gentleman could thus combine ordinary stereoscopic pictures with the naked eyes beyond the plane of the pictures, even when the distance between identical points was greater than the distance between the centers of his pupils. His ocular

divergence was very small, and therefore, as might have been expected, in proportion as the distance between identical points of the pictures was greater, the distance from the eyes at which the pictures must be placed must also be greater. For instance: when the distance between identical points was three inches the pictures were held at arm's length; when the distance was six inches the pictures were placed on the other side of the room. It would be curious to enquire, at what *distance* and of what *size*, according to the laws of vision, the stereoscopic image ought to seem in this case. For while one condition of single vision, the absolutely necessary one, viz: that the retinal images shall occupy corresponding points on the two retinæ, is satisfied; another condition. which if not absolutely necessary, is present in every act of single vision except this one—a condition which determines the apparent place and size of the object or stereoscopic image—viz: the *meeting of the two visual lines, is not satisfied.* In all cases of single vision, whether of natural objects or by stereoscopic combinations, the object or stereoscopic image is seen at the intersection of the visual lines, which is therefore called the *point of sight.* But in this case there is no point of sight at all—the visual lines do not meet at all except behind the head.

In one of my papers on binocular vision* I gave a new method of representing the position of double images; a method which, however, represents equally well the position of images




seen single by stereoscopic combination. The facts which I have just presented may be perfectly represented by this method, but cannot by any other. Let R and L (fig. 1) represent the position of the eyes in sleepiness, and A the object

* This Jour., Ser. III, vol. i, p. 33.

contemplated; then the lines A N, L*v* R*v*, will represent the position of the median line and the two visual lines and R A, L A of the ray-lines from the object A to the eyes. The visual result, if all these lines were visible, is represented by fig. 2. The object A, fig. 1, is seen double at *a* and *a'*, fig. 2. If, instead of one object at A, there be two similar objects, e. g., stereoscopic pictures at *v* and *v*, fig. 1, then these will combine and be seen single at V somewhere along the combined visual lines E V, fig. 2. Of course there will be seen also, unless cut off by a septum, two other images, *v* and *v'*, to the extreme right and left, as already explained in my previous paper. I cannot even conceive how these phenomena can be represented by the usual method.

VIII. *In binocular vision the law of corresponding points may be opposed to the law of direction. In such cases the law of corresponding points prevails.*

There are two well known fundamental laws of vision, viz: the *law of visible direction* and the *law of corresponding points.** The one is the fundamental law of *monocular*, as the other is of *binocular* vision. The one gives the true position of all objects and radiants, and therefore completely explains erect vision with *inverted* retinal image; the other combines the double external images of the same object at the point of sight, and therefore completely explains *single* vision with *double* retinal images. The former is usually regarded as the more fundamental—as underlying and explaining the other law, and as therefore itself capable of explaining all the phenomena of

* The law of *visible direction* may be thus expressed: Every impression on the retina reaching it by a ray line passing through the optic center, is *referred back along the same ray line* to its true place in space. Thus for every *radiant* point in the object there is a corresponding *focal* point in the retinal image, and every focal point is referred back along its ray line to its corresponding radiant, and the *external* image (object) is thus re-constructed in its proper position. Or it may be otherwise expressed thus: Space in front of us is, under all circumstances, an *outward projection of retinal states*. With the eyes *open*, the field of *view* is the outward projection of the *active* state; with the eyes *shut*, the field of *darkness* is an outward projection of the *passive* state of the retina. Thus the internal retinal concave with all its states is projected outward and becomes the external spatial concave, and the two correspond point for point. Now the lines connecting the corresponding points internal and external intersect each other at the optic center, and impressions reach the retina and are referred back into space along these lines. This would give the true position of all objects and radiants, and therefore completely explains erect vision with inverted retinal image.

The law of corresponding points may be thus briefly expressed: Imagine the two eye-balls placed together in such wise that they geometrically coincide throughout, then the coincident points of the two retinæ are what are called corresponding points. Now the law of corresponding points declares that images or impressions of any kind falling upon corresponding points of the two retinæ are referred back to the same place in space and therefore seen single, while impressions falling on non-corresponding points are seen double. The determination of the horopter, as a geometric problem, is the determination of the surface or line, the ray lines from every point of which would impress corresponding points of the retinæ.

vision both monocular and binocular. The law of visible direction does indeed explain all the *ordinary* phenomena of single vision with two eyes; for in all ordinary cases of single vision—in all ordinary voluntary acts of binocular sight—in all cases of vision of objects lying in the horopter (whether this be a line or a surface), since ray lines from an object or radiant come to each eye from the same spot in space, by the law of direction the two images must be referred back along these ray lines to the same spot and therefore *superposed* and *seen single*. Thus single vision becomes in these cases a necessary result of the law of direction, and the law of corresponding points becomes only a particular case of the more general law of direction.

But in all cases of *double* images, the apparent position of these to the binocular observer is always different, and in some cases very different from the true position of the object which they represent. The difference may amount even to 45°. For example: The binocular field of view in my own case is about 100° in a horizontal direction. By strong convergence I can almost wholly obliterate this common field. In such case the images of objects lying near the extreme margins of the common field, and therefore at least 90° apart, are brought together and united in the middle, and seen apparently directly in *front;* while objects really in front are doubled and their images are separated 90° from each other, and each 45° from the true position of the object which they represent.

Fig. 3 represents the actual position of parts in this experiment, R and L being the right and left eye respectively, N the

root of the nose, *a a′* objects in the visual line 45° to the right and left, M N the median line and M an object in front; and figure 4 is the visual result represented by my method. It will be seen by comparing the two figures that the two eyes R and L are combined and rectified to form the single binocular eye E, the visual lines R*a* and L*a′* become the common visual

line A E, the objects *a* and *a'* combine at A, while the median line and the object M are doubled and the images of the latter are seen at *m* and *m'*.*

It is true that in the case of the objects *a* and *a'* seen directly in front, it may be argued that this visual result is not in violation of the law of visible direction, but is in fact easily explained by that law. For if the combined images be referred to the point of ocular convergence (*c*, fig. 3) as in fact they often are, then each eye sees its own object in the true *direction* but only mistakes their *distance*. To this I answer, that *each eye* does indeed give the true direction, as is quickly shown by shutting one eye, but the *two eyes* do not. Each eye sees its own object in the true direction, but the *binocular observer* sees their combination in a wrong direction. The law of direction is true in all cases in *monocular* vision, but is not always true in *binocular* vision. In the case of the double images *m* and *m'* of the object M, it is still more difficult to explain their apparent position by the law of direction.

I suppose, however, that in all cases of ocular *convergence* it may be possible by an ingenious device to save the law of direction; but in the case of ocular *divergence* it is impossible by any device to explain the position of double images by that law. The position of images in this case is in direct violation of that law; the laws of direction and of corresponding points are in contradiction to each other and the *law of corresponding points prevails*. This we now proceed to show.

We have seen, p. 160 and figs. 1 and 2, that in drowsiness the optic axes may diverge 20°, and that in such cases the double images of an object in *front* are seen right and left 10° from the real position of the object which they represent; and on the other hand, that objects really in the direction of the visual lines, and therefore 20° apart, are combined and seen directly in front. Unfortunately, we cannot diverge the optic axes voluntarily and therefore cannot make experiments of this kind at will; but by pressing the eye-balls on their outer side the axes may be made to diverge considerably. By strong, almost painful pressure on the outer portion of both eye-balls, I have succeeded in making the double images of an object directly in front separate 50°, and those of objects 50° apart combine directly in front. There can be no doubt that if we could turn our eyes directly outward, or if our eyes, retaining

* By comparing these figures with those of my previous paper, it will be seen that I have modified slightly the mode of representation by including the parts of the face itself in the rotation, as well as in the *shifting*, of the field of view of each eye. In *convergence* this brings the two images of the nose nearer together in front and thus narrows the common field, which is exactly what actually happens. In divergence, on the contrary, the double images of the nose separate and the common field is widened.

their present organization, were transferred to the sides of our heads, with their axes directed straight right and left, and therefore making an angle of 180° with each other, *images of objects in the direction of these axes, and therefore directly right and left, would be moved round* 90° *each and combined and seen directly in front.* This seems an extraordinary result, but is a necessary consequence of the law of corresponding points. The retinal images of the two objects are on corresponding points; by the law of corresponding points, therefore, they must be seen as *one.* But where else can this take place but in front.

The foregoing results, as extraordinary as they may seem, are completely explained by the principles brought out in my previous papers, especially that "On the mode of representing the position of double images," and that "On so-called images of illusion."* Those who have read these papers will remember that I have there shown that there are two apparent movements of the field of view accomplished by the eyes in binocular vision. The first is a bodily *shifting* of the field of the right eye one-half interocular distance to the left, and of the field of the left eye the same distance to the right; so that the two eyes are brought together in the middle and combined to form a *single binocular eye*, and the two visual lines combined to form a common visual line. This movement is habitual and involuntary, but it produces little change in the apparent position of objects unless they be very near. The second is a *rotation* of the whole field of view of both eyes about the optic center, whenever the two eyes move in opposite directions, as in *convergence* or *divergence.* This rotation is always in a direction opposite to the motion of the eyes, and therefore homonymous in convergence and heteronymous in divergence. It is this movement which changes so greatly the apparent position of all objects in the field of view under the conditions mentioned, and it is this, therefore, which concerns us in the explanation of the phenomena related above. In monocular vision, as also in binocular, when the eyes move together right or left, up or down, external objects seem stationary, and the visual lines seem to move across them. But in binocular vision, when the two eyes move in opposite directions, the visual line seems to remain stationary (i. e., we seem to look in the same direction), while external *objects* or their images seem to move. In converging or diverging the optic axes, the external images belonging to each eye, like trooping shadows, seem to sweep in opposite directions, toward each other in convergence, away from each other in divergence. As the visual lines *actually* approach and sweep across objects successively, the images of these objects *seem* to advance and

* This Jour., III, vol. i, p. 33, and vol. ii, pp. 314 and 417.

take their places successively in front of the observer. And this is true whatever the degree of convergence or divergence. In all cases, whatever be the position of the eyes, objects in the visual lines, and whose retinal images therefore fall on the central spots of the retinæ, are seen in front. If therefore the two eyes could be turned directly outward, or if the eyes were placed on the sides of the head so that the optic axes were directed straight right and left, objects directly right and left would be seen in front, and therefore 90° from their true position.

## IX. *Comparative Physiology of Binocular Vision.*

For many years past I have reflected much, and attempted to make some observations, on the phenomena of vision of lower animals, for the purpose of testing the existence or non-existence of binocular vision in them. I must frankly confess I have accomplished but little. The phenomena of binocular vision are so essentially subjective, that it seems almost impossible to reach any satisfactory results by observations or experiment. As the subject, however, as far as I know, has never been touched, I will bring forward my somewhat crude thoughts, in the hope that others may follow them up with more success.

In man the axes of the conical eye-sockets diverge about 25°, or each makes an angle with the median line of about 12°. In these slightly diverging conical sockets, the eye-balls are so placed, and the muscles so adjusted, that in the waking passive state their axes are parallel; and from this passive parallel condition they may easily be converged even upon very near objects. In man, then, though the eye-sockets still diverge considerably, the eyes are set in front with axes naturally parallel. This is evidently the position most suitable for binocular vision.

In monkeys the position of the eyes is much the same as in man. They are placed well in front, near together, their axes apparently parallel, and therefore well adapted to binocular convergence. But as we go down the vertebrate scale, the eyes are placed wider and wider apart; the axes of the eye-sockets diverge more and more, the difficulty of convergence upon a near point becomes greater and greater, until in some mammals, such as the Cetaceæ, in most birds and in all fishes, the eyes are placed no longer in front, but on the sides of the head, with their optic axes inclined nearly or quite 180° to each other. It seems quite evident that animals with eyes so placed cannot converge the optic axes on a single point, especially a near point. In fact, it is well known that most birds, when viewing an object very attentively, turn the head on one side

and *look with one eye.* It seems impossible that the law of corresponding points can exist for these animals; for if it did, as we have already seen (p. 167), it would only lead to constant and fatal mistakes as to the position of external objects. In a word, it is impossible that these animals can enjoy a true binocular vision, with its double and its combined images, its stereoscopic effects, and the complex but accurate visual judgments founded on these effects. They see indeed with two eyes; but these do not act together as one instrument—as a single binocular eye; they are independent and see each for itself. This is the case with the other senses even in man. However much their organs may be multiplied, each organ perceives for itself. The property of corresponding points, from which arise all the phenomena of binocular vision, is something peculiar to the eye. Nothing analogous exists in the other senses. Binocular vision in its perfection, as it exists in man, is the last result of the gradual improvement of that most refined and wonderful instrument, the eye; specially adapting it to meet the wants of the higher faculties of the mind.

Below the vertebrates, of course, binocular vision does not and cannot exist.

There is another peculiarity of the human eye, probably closely connected with binocular vision, which still more quickly disappears as we go down the vertebrate scale. I refer to the existence of the so-called yellow spot or *central spot* of the retina.

It is well known that in the very center of the retina, just where the optic axis or continuation of the visual line pierces the retina, and therefore just where the images of objects in the visual line fall, there is a small depression about $\frac{1}{150}$ inch in diameter, bordered by a yellow margin. This depression is called the central spot. It is the most highly organized and most sensitive spot of the retina. It differs from other portions, 1st, in the fact that here the layer of rods and cones, the true receptive organ of the retina, is not covered by the fibrous layer, but directly exposed to the impression of light; and 2d, in the fact that here the cones are much smaller and more numerous than elsewhere.

Now it is a familiar fact that while gazing steadily at a certain point we see very clearly only a very small area about the point of sight. This small area corresponds, point for point, to the central spot of the retina. If now, while gazing steadily, we observe the relative distinctness of vision in other portions of the field of view, we shall find that it becomes less and less distinct in proportion as the point observed is more distant from the line of sight. In other words, there is a perfect graduation of distinctness from the point of sight, where it is greatest, to the

margins of the visible field, where it is least. Now as the retina corresponds with the visible field point for point, it follows that there is a corresponding graduation, certainly in sensitiveness, probably in fineness of organization of the receptive layer of the retina, from the central spot even to the extreme anterior margin. Except in the central spot this increasing fineness of organization has not been demonstrated, but it doubtless exists, for the increasing distinctness of vision toward the point of sight is its effect and its representative in the field of view.

As we go down the vertebrate scale, the central spot is found only in some monkeys. After a total absence in other mammals and in all birds, it is said to reappear in some lizzards; but whether it there has the same structure, and therefore the same significance, as in the human eye is not certain. It seems fair to conclude, therefore, that the graduation of distinctness toward the point of sight and the limitation of the greatest distinctness to that point, do not exist in most of the lower animals.

The importance of the central spot in the highest animals, and especially in man, is very evident. The limitation of the greatest distinctness to the point of sight is absolutely necessary to the *concentration and limitation of the most thoughtful attention* to that point. If all portions of the retina were similarly organized, and therefore all points in the field of view equally distinct, it would be impossible to fix the attention steadily and thoughtfully on any one point to the exclusion of others. We might *see* equally well and over a wider field, but we could not *look* attentively. We could not *observe* thoughtfully. But in the lower animals, especially those which are preyed upon by others, it is far more important to see well in every direction than to fix the attention too exclusively on one point; the advantages of exquisite microscopic distinctness of the center of the field is sacrificed for the much greater advantages of moderate distinctness over a very wide field. The most important thing for them is a very wide field, and the equal distribution of attention over every part. Hence their eyes are prominent, set wide apart on the margins of the front or on the sides of the head, and destitute of central spot; so that they sweep the whole horizon and see all parts with nearly equal distinctness.

The connection of the central spot with binocular vision is also quite evident. These central spots are, more than all others, endowed with the properties of corresponding points, and the somewhat complex binocular judgments expressed by the words "stereoscopic perspective" are accurate and reliable only in the vicinity of the point of sight. This is the great difficulty in the way of experimental determination of the horopter, as already explained in one of my early papers.*

* This Jour., II, vol. xlvii, p. 153.

The following, then, are the general changes in the vertebrate eye, as we go up the scale: 1. A gradual change of the *position* of the eyes from the *sides* to the *front* of the head, and a consequent change of the angle of inclination of the optic axes from 180° to parallelism. 2. A gradually increasing graduation of the fineness of organization, and therefore the sensitiveness of the retina, from the anterior margins toward the central parts, so as finally to form in monkeys and in man a central spot. 3. A gradually increasing power of converging the optic axes upon a single near point, so that the images of that point may fall upon the central spots of both eyes. 4. The gradual evolution of the properties of corresponding points, and therefore of all the distinctive phenomena of binocular vision.

These changes seem all intimately connected with each other and with the development of the higher faculties of the mind.

Oakland, Cal., Oct. 26, 1874.

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ART. XIX.—*Jeffries Wyman. Address of Professor* A. GRAY at the Memorial Meeting of the Boston Society of Natural History, Oct. 7, 1874.*

[Concluded from page 93.]

IN attempting these analyses, I am drifting into a fault which Prof. Wyman never committed, that of being too long. So I must leave many of his papers unmentioned, and barely refer to two or three others which cannot be passed over. The most noteworthy of the shorter papers, however, are upon less technical or more generally interesting topics, so that we have need only to be reminded of them. Among them are his "Observations on the Development of the Surinam Toad," and the same of "*Anableps Gronovii*," and the paper "On some unusual Modes of Gestation." The importance of these papers lies, not in being accounts of some of the most striking curiosities of the animal world, but in the sagacity and quickness with which he discerned, and the clearness with which he taught, the lessons to be learned from them. Any good zoologist, with the same excellent opportunities, would have worked out all the details of the development of the Surinam toads in the skin of the back of their mother, and would equally have noted the morphological significance of the branchiæ and tail, that are never to know any thing of the element they are adapted for; but Dr. Wyman remarks upon the development of the limbs independently of the vertebral axis, as showing

* From the "Proceedings" of the Society.

that, whatever view be taken of their homology, they are something superadded to it, and not evolved from it; he notes how the *whole* yelk-mass is moulded into a spiral intestine; and that the embryo at the end of incubation forms a larger and heavier mass than existed in the egg when it commenced, —showing that there was an absorption of material furnished by the dermal sac of the mother,—"a solitary instance among Batrachians, if not among Reptiles generally, in which the embryo is nourished at the expense of materials derived from the parent." From this he is led (in the later paper above mentioned) to infer the probability that the developed larvæ of *Hylodes lineatus*,—carried about inland upon the back of their mother, and destitute of limbs adapted to terrestrial locomotion,—may depend upon a secretion from the body for needful sustenance—an interesting and rudimentary foreshadowing of mammalian life, of which he discerned the bearings.

His "Description of a Double Fœtus" (in the Boston Medical and Surgical Journal, March, 1866) gives him the opportunity of briefly recording some of the results of his studies of the development of double monsters, and to bring out his view, that "the force, whatever it be, which regulates the symmetrical distribution of matter in a normal or abnormal embryo, has its analogy, if anywhere, in those known as polar forces;" that "studying the subject in the most general manner, there are striking resemblances between the distribution of matter capable of assuming a polar condition and free to move around a magnet, and the distribution of matter around the nervous axis of an embryo." That this is not one of those vague conceptions by which many speculators set about to explain that of which they know little by means of that of which they know less, but that he had striking parallelisms to adduce, the close of this striking paper shows.

The subject of fore and hind symmetry, thus brought directly under notice, had been broached by Dr. Wyman several years before. He returned to it the year following, in his very important morphological paper, "On Symmetry and Homology in Limbs," read to this society in June, 1867, and published in the Proceedings of that date. It is interesting to observe with what caution and restraint he handled this doctrine of "reversed repetitions," which has since been freely developed by one of his pupils, who has a special predilection for speculative morphology, Prof. Burt Wilder.

Prof. Wyman's "Notes on the Cells of the Bee," in the Proceedings of the American Academy for January, 1866, is a characteristic specimen of his way of coming directly down to the facts, and making them tell their own story. I could not recapitulate his results much more briefly than he records

them in his paper. I need not recall to you how neatly he made this investigation, and represented some of the results, filling the comb with plaster-of-paris and then cutting it across midway, so that the observations might be made and the cells measured just where they are most nearly perfect; and then printing impressions of the comb upon the wood-block, he reproduces on the pages of his article the exact outlines of the cells, with all their irregularities and imperfections. But I cannot refrain from citing a portion of his remarks at the close:—

"Here, as is so often the case elsewhere in nature, the type-form is an ideal one; and with this real forms seldom or never coincide. . . . . An assertion, like that of Lord Brougham, that there is in the cell of the bee 'perfect agreement' between theory and observation, in view of the analogies of nature is more likely to be wrong than right; and his assertion in the case before us is certainly wrong. Much error would have been avoided if those who have discussed the structure of the bee's cell had adopted the plan followed by Mr. Darwin, and studied the habits of the cell-making insects comparatively, beginning with the cells of the humble-bee, following with those of wasps and hornets, then with those of the Mexican bees (*Melipona*), and finally with those of the common hive-bee. In this way, while they would have found that there is a constant approach to the perfect form, they would at the same time have been prepared for the fact, that even in the cell of the hive-bee perfection is not reached. The isolated study of anything in natural history is a fruitful source of error."

Let me add to this important aphorism its fellow, which I have from him, but know not if he ever printed it. "*No single experiment in physiology is worth anything.*"

The spirit of these aphorisms directed all his work. It is well exemplified in his experimental researches—the last which I can here refer to,—upon "The formation of Infusoria in boiled solutions of organic matter, enclosed in hermetically sealed vessels and supplied with pure air," and its supplement, "Observations and Experiments on living organisms in heated water," published in the American Journal of Science and Arts, the first in the year 1862, the other in 1867. Milne-Edwards could not have known the man, when he questioned the accuracy of the first series because they do not agree with those of Pasteur, and thought the difference in the results depended upon a defective mode of conducting the experiments. As Dr. Wyman remarks in a note to the second series, "the recent experiments of Dr. Child of Oxford, and those reported in this communication, are sufficient answer to the criticisms

of M. Edwards." Then as to his thoroughness: most persons would have rested on the results of his thirty-three well-devised experiments, proving "that the boiled solutions of organic matter made use of, exposed only to air which has passed through tubes heated to redness, became the seat of infusorial life;" but all would not have concluded that, after all, they "throw but little light on the immediate source from which the organisms have been derived," nor would many have closed an impartial summary of the opposing views in this judicial way:—

"If, on the one hand, it is urged that all organisms, in so far as the early history of them is known, are derived from ova, and therefore from analogy we must ascribe a similar origin to these minute beings the early history of which we do not know, it may be urged with equal force, on the other hand, that all ova and spores, in so far as we know anything about them, are destroyed by prolonged boiling; therefore from analogy we are equally bound to infer that Vibrios, Bacterians, etc., could not have been derived from ova, since these would all have been destroyed by the conditions to which they have been subjected. The argument from analogy is as strong in the one case as in the other."

Returning to the subject again a few years later, with a critical series of twenty experiments, each of three, five, ten, fifteen, or even twenty flasks, used by way of checks and comparisons, —a rigorous experimenter would have been satisfied when he had proved that sealed solutions, subjected to a heat of at least 212° for from *one* to *four* hours, became the seat of infusorial life, at least of such as Vibrios, Bacterians and Monads, while all infusoria having the faculty of locomotion were shown by a special series of experiments to lose this at a temperature of 120°, or at most 134° Fahr. But Prof. Wyman carried the boiling up to *five* hours, and in these flasks no infusoria of any kind appeared. The question of abiogenesis stands to-day very much where Prof. Wyman left it seven years ago.

I must omit all notice of the ethnological work which has occupied his later years, merely referring to the seven Annual Reports of the Trustees of the Peabody Museum of American Archæology and Ethnology, of which he was curator. The last of these, issued just before the writer's death, contains the principal results of his investigation of the human remains he collected in the shell-heaps of East Florida, and convincing evidence of the cannibalism of those who made them. A fuller memoir, embodying all his observations of the last six winters upon the Florida shell-mounds, was sent to the printer just before he died.

The thought that fills our minds upon a survey even so incomplete as this is: How much he did, how well he did it all, and how simply and quietly! We knew that our associate, though never hurried, was never idle, and that his great repose of manner covered a sustained energy; but I suspect that none of us, without searching out and collecting his published papers, had adequately estimated their number and their value. There is nothing forth-putting about them, nothing adventitious, never even a phrase to herald a matter which he deemed important.

His work as a teacher was of the same quality. He was one of the best lecturers I ever heard, although, and partly because, he was the most unpretending. You never thought of the speaker, nor of the gifts and acquisitions which such clear exposition were calling forth,—only of what he was simply telling and showing you. Then to those who, like his pupils and friends, were in personal contact with him, there was the added charm of a most serene and sweet temper. He was truthful and conscientious to the core. His perfect freedom, in lectures as well as in writing, and no less so in daily conversation, from all exaggeration, false perspective, and fictitious adornment, was the natural expression of his innate modesty and refined taste, and also of his reverence for the exact truth.

It has been a pleasure to learn, from former college students, who hardly ever saw him except in the lecture-room, that he gave to them much the same impression of his gifts and graces, and sterling worth, that he gave us who knew him intimately —so transparent was he, and natural.

With all his quick sense of justice, and no lack of occasion for controversy, it seemed to cost him no effort to avoid it altogether. He made no enemies, and was surrounded by troops of life-long friends. When he first went abroad, in 1841, he was told by some near friends, who recognized his promise, that a chair of Natural History in his alma mater would soon have to be filled, and that he should be presented as a candidate. In the winter following the present incumbent, responding to an invitation to visit Boston, which he had never seen, and to consider if he would be a candidate, then first heard of Wyman's name and of his friends' expectations or hopes; whereupon he dismissed the subject from his mind. Probably he felt more surprise than did Dr. Wyman, when notified, a few months afterward, of the choice of the Corporation. The exigencies of the Botanic Garden probably overbore other considerations. I doubt if Dr. Wyman ever had an envious feeling. Certain it is that no one welcomed the new professor with truer cordiality, or proved himself a more constant friend.

In these days it is sure to be asked how an anatomist, physiologist, and morphologist like Prof. Wyman regarded the most

remarkable scientific movement of his time, the revival and apparant prevalence of doctrines of evolution. As might be expected, he was neither an advocate nor an opponent. He was not one of those persons who quickly make up their minds, and announce their opinions, with a confidence inversely proportionate to their knowledge. He could consider long, and hold his judgment in suspense. How well he could do this appears from an early, and so far as I know, his only published presentation of the topic, in a short review of Owen's "Monograph of the Aye-Aye" (in Am. Journ. Science, Sept., 1863)—the paper in which Prof. Owen's acceptance of evolution, but not of natural selection, was promulgated. Dr. Wyman compares Owen's view with that of Darwin (to whom he had already communicated interesting and novel illustrations of the play of natural selection); and he adds some acute remarks upon a rather earlier speculation of Mr. Agassiz, in which the latter suggests that the species of animals might have been created as eggs rather than as adults. He states the case between the two general views with perfect impartiality, and the bent of his own mind is barely discernible. In due time he satisfied himself as to which of them was the more probable, or, in any case, the more fertile hypothesis. As to this, I may venture to take the liberty to repeat the substance of a conversation which I had with him some time after the death of the lamented Agassiz, and not long before his own. I report the substance only, not the words.

Agassiz repeated to me, he said, a remark made to him by Humboldt, to the effect that Cuvier made a great mistake, and missed a great opportunity, when he took the side he did in the famous controversy with Geoffroy St. Hilaire; he should have accepted the doctrines of morphology, and brought his vast knowledge of comparative anatomy and zoology, and his unequalled powers, to their illustration. Had he done so, instead of gaining by his superior knowledge some temporary and doubtful victories in a lost cause, his preëminence for all our time would have been assured and complete. I thought, continued Wyman, that there was a parallel case before me,—that if Agassiz had brought his vast stores of knowledge in zoology, embryology, and palæontology, his genius for morphology, and all his quickness of apprehension and fertility in illustration, to the elucidation and support of the doctrine of the progressive development of species, science in our day would have gained much, some grave misunderstandings been earlier rectified, and the permanent fame of Agassiz been placed on a broader and higher basis even than it is now.

Upon one point Wyman was clear from the beginning. He did not wait until evolutionary doctrines were about to prevail,

before he judged them to be essentially philosophical and healthful, "in accordance with the order of Nature, as commonly manifested in her works," and that they need not disturb the foundations of natural theology.

Perhaps none of us can be trusted to judge of such a question impartially, upon the bare merits of the case; but Wyman's judgment was as free from bias as that of any one I ever knew. Not at all, however, in this case from indifference or unconcern. He was not only, philosophically, a convinced theist, in all hours, and under all "variations of mood and tense," but personally a devout man, an habitual and reverent attendant upon Christian worship and ministrations.

Those of us who attended his funeral must have felt the appropriateness for the occasion of the words which were there read from the Psalmist:—

"The Heavens declare the glory of God, and the firmament showeth his handy-work. . . . . O Lord, how manifold are thy works! In wisdom hast thou made them all; the earth is full of thy riches; so is this great and wide sea, wherein are things creeping innumerable, both great and small beasts. Thou sendest forth thy spirit, they are created, and thou renewest the face of the earth."

These are the works which our associate loved to investigate, and this the spirit in which he contemplated them. Not less apposite were the Beatitudes that followed:—

*Blessed are the meek; blessed are the peace-makers; blessed are the merciful; blessed are the pure in heart.*

Those who knew him best, best knew how well he exemplified them.

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ART. XX.—*Brief Contributions to Zoology from the Museum of Yale College.* No. XXXI.—*The Gigantic Cephalopods of the North Atlantic;* by A. E. VERRILL.

(Continued from page 130.)

ACCOUNTS of an attack made upon two men by another gigantic cephalopod, in Conception Bay, Oct. 27, 1873, have been published in this Journal,* and in many other magazines, as well as in the newspapers. In the encounter the monster lost two of his arms by amputation with a hatchet. A portion of one of these arms, measuring nineteen feet in length, was preserved by Rev. M. Harvey and Mr. Alexander Murray for the museum at St. John's, Newfoundland. It has been photographed, and cuts copied from the photograph have been pub-

* See vol. vii, p. 158, 1874; and American Naturalist, vol. viii, No. 2, p. 120, February, 1874, in a letter from Mr. Alexander Murray.

lished in some of the English magazines.* Before it was secured for preservation it had been considerably injured, many of the larger suckers having been torn off or mutilated. Owing to this fact they were originally described by Mr. Harvey as destitute of marginal denticulations, but he has recently re-examined the specimen, at my request, and now informs me that he is satisfied that they were all originally denticulated. Of this specimen I have seen only the photograph and some of the smaller suckers.

It is stated that six feet of this arm had been destroyed before it was preserved, and the captors estimated that they left from six to ten feet attached to the creature, which would make the total length between 31 and 35 feet. According to Mr. Murray, the portion preserved measured but 17 feet in length, when he examined it, Oct. 31, 1873, after it had been a few days in strong brine; the circumference of the slender portion was 3·5 to 4 inches; of the enlarged sucker-bearing part, 6 inches; length of the part bearing suckers, 30 inches; diameter of largest sucker, 1·25 inches. Calculating from the photograph, the portion bearing the larger suckers was about 18 inches in length, and about 2·4 inches broad, across the face; distance between attachments of large suckers, 1·68; outside diameter of larger suckers, 1·16 to 1·28; inside diameter, ·74 to 1 inch; diameter of small suckers of the outside rows, ·40 to ·48 of an inch. Mr. Harvey has recently sent to me a full series of measurements of this arm, as now preserved. It has contracted excessively in the alcohol, and is now only 13 feet and one inch in length (instead of 19 feet, its original length), the enlarged sucker-bearing portion being 27 inches; the large suckers occupy 12 inches; the terminal part bearing small suckers, 9 inches; circumference of slender portion 3·5 to 4·25 inches; of largest part 6 inches; breadth of face, among large suckers, 2·5 inches; from face to back, 1·62 inches; diameter of largest suckers outside, ·75 of an inch; inside, ·63 of an inch. It will be evident from these measurements, when compared with those made while fresh and from the photograph, that the shrinkage has been chiefly in length, the thickness remaining about the same, but the suckers are considerably smaller than the dimensions previously given. Comparing all these dimensions with those of the Logie Bay specimen, and calculating the proportions as nearly as possible, it follows that this specimen was very nearly one-third larger than the latter, but the large suckers appear to have been relatively smaller, for they were hardly one-twelfth larger than in

* See Annals and Magazine of Natural History, IV, xiii, p. 68; and "The Field," Dec. 13, 1873. The central line of this photograph is reduced four and a quarter times, while the front part is reduced about four times.

the Logie Bay specimen. As the relative size of the large suckers is a good sexual character among squids, it is probable that this individual was a *female*. In form, proportions and structure, it agrees very closely with the specimen first described, and therefore I do not hesitate to refer it to the same species. The fishermen estimated the body of this individual to have been about 60 feet in length and 5 feet in diameter; but if the above proportions be correct, as I believe, then the body could not have been more than about 10 feet long, and 2·5 in diameter, and the long arms should have been about 32 feet in length. Allowing two feet for the head, the total length would, therefore, be about 44 feet.

Another specimen (No. 3), probably of the same species, and similar in size to the last, was captured at Coombs' Cove, Newfoundland. The following account has been taken from a newspaper article of which I do not know the precise date, forwarded to me by Professor Baird, together with a letter, dated June 15, 1873, from T. R. Bennett, Esq., of English Harbor, N. F., who states that he wrote the article, and that the measurements were made by him, and are perfectly reliable.

"Three days ago, there was quite a large squid run almost ashore at Coombs' Cove, and some of the inhabitants secured it. The body measured 10 feet in length and was nearly as large round as a hogshead. One arm was about the size of a man's wrist, and measured 42 feet in length; the other arms were only 6 feet in length, but about 9 inches in diameter, very stout and strong. The skin and flesh were 2·25 inches thick, and reddish inside as well as out. The suction cups were all clustered together, near the extremity of the long arm, and each cup was surrounded by a serrated edge, almost like the teeth of a hand-saw. I presume it made use of this arm for a cable, and the cups for anchors, when it wanted to come to, as well as to secure its prey, for this individual, finding a heavy sea was driving it ashore, tail first, seized hold of a rock and moored itself quite safely until the men pulled it on shore."

It would appear from this description that one of the long arms had been lost before the capture. The large diameter of the short arms, compared with their length, and with the size of the long arms, is the only point in which this specimen apparently differed essentially from those described above. Possibly the *circumference* was intended,* which would make the proportions agree well with those of the other specimens.

In a letter from Mr. Harvey, dated Dec. 10, 1873, he says that the Speaker of the House of Assembly stated to him that

* A similar mistake actually occurred in the description of the long arms, in the letter from Mr. Murray, published in the American Naturalist for February, 1873, p. 122, referred to above, but in that instance the error was very obvious.

he had measured a specimen cast ashore in Fortune Bay, which was between 42 and 43 feet in length, the body and head together being between 12 and 13 feet, and the two long arms each 30 feet. This we may designate as No. 6.

Dr. Honeyman, geologist of Nova Scotia, has published, in a Halifax paper, a statement made to him by a gentleman who claims to have been present at the capture of another specimen (No. 7) in the Straits of Belle Isle, at West St. Modent, on the Labrador side. "It was lying peacefully in the water when it was provoked by the push of an oar. It looked fierce and ejected much water from its funnel; it did not seem to consider it necessary to discharge its sepia, as mollusca of this kind generally do, in order to cover their escape." * * * * "The length of its longest arm was 37 feet; the length of the body 15 feet; whole length 52 feet. The bill was very large. The suckers of its arms or feet, by which it lays hold, about 2 inches in diameter. The monster was cut up, salted, and barrelled for dog's meat." In this account the length given for the "body" evidently includes the head also. This creature was probably disabled, and perhaps nearly dead, when discovered at the surface, and this seems to have been the case with most of the specimens hitherto seen living. Animals of this sort probably never float or lie quietly at the surface when in good health.

Mr. Harvey also refers to a statement made to him by a clergyman, Rev. M. Gabriel, that two specimens (Nos. 8 and 9), measuring respectively 40 and 45 feet in total length, were cast ashore at Lamaline, on the southern coast of Newfoundland, in the winter of 1870–71. These may also have been of the same species as those described above, all of which I now refer to *Architeuthis monachus* of Steenstrup.

Mr. Harvey also mentions, in a recent letter, that a specimen was cast ashore at Bonavista Bay, December, 1872, and his informant says that the long arms measured 32 feet in length, and the short arms about ten feet in length, and were "thicker than a man's thigh." The body was not measured, but he thinks it was about fourteen feet long, and very stout, and that the largest suckers were 2·5 inches in diameter. The size of the suckers is probably exaggerated, and most likely the length of the body also. It is even possible that this was the same specimen from which the beak and suckers described in my last article, as No. 4, from Bonavista Bay, were derived, for the date of capture of that specimen is unknown to me. The latter, however, was much smaller than the above measurements, and it will, therefore, be desirable to give a special number (11) to the former.

Another specimen, which we may designate as No. 12, was cast ashore this winter, near Harbor Grace, but was destroyed before its value became known, and no measurements are given.

*Architeuthis princeps* Verrill. Plate v, figures 14, 15, 16.—This species is based on the lower jaw mentioned as No. 1 in my former papers, and on the upper and lower jaws designated as No. 10, in the first part of this article; besides these jaws we only have the rough measurements of the body of No. 1, and an estimate of the diameter of the sessile arms. The jaws of No. 10 were obtained from the stomach of a sperm whale taken in the N. Atlantic, and were presented to the Essex Institute by Capt. N. E. Atwood, of Provincetown, Mass., but the date and precise locality of the capture are unknown. The form of these jaws is well shown in figures 14 and 15. The total length of the upper jaw (fig. 14) is 5 inches; greatest breadth, 1·45; front to back, 3·5 inches; width of palatine lamina, 2·32. The frontal portion is considerably broken, but the dorsal portion appears to extend nearly to the posterior end, the length from the point of the beak to the posterior edge being 3·4 inches. The texture is firmer and the lamina are relatively thicker than in *A. monachus*. The rostrum and most of the frontal regions are black and polished, gradually becoming orange-brown and translucent toward the posterior border, and marked with faint striæ radiating from the tip of the beak, and by faint ridges or lines of growth parallel with the posterior margin; a slight but sharp ridge extends backward from the notch at the base of the cutting edge, and other less marked ones from the anterior border of the alæ. The tip of the beak is quite strongly curved forward, and acute, with a slight shallow groove, commencing just below the tip, on each side, and extending backward only a short distance and gradually fading out. The cutting edge is nearly smooth and well curved, the curvature being greatest toward the tip; at its base there is a broad angular notch, deepest externally. The inner face of the rostrum is convex in the middle and concave or excavated toward the margins, which are, therefore, rather sharp. The anterior borders of the alæ are convex, or rise into a broad, but low, lobe or tooth beyond the notch, but beyond this they are nearly straight, but with slight, irregular lobes, which do not correspond on the two sides. The anterior edges of the alæ make nearly a right angle with the cutting edges of the rostrum. The palatine lamina is broad, thin, and dark brown, becoming reddish brown and translucent posteriorly, with a thin, whitish border. The surface is marked with unequal divergent striæ and ridges, some of which, especially near the dorsal part, are quite prominent and irregular; the posterior border has a broad emargination in the middle, but the two sides do not exactly correspond. The lower jaw (plate v, fig. 15) was badly broken, and many of the pieces, especially of the alæ, are lost, but all that remain have been

fitted together. The extreme length is 3·63 inches; the total breadth, and the distance from front to back, cannot be ascertained, owing to the absence of the more prominent parts of the alæ; from tip of beak to posterior dorsal border of mentum, 1·68; from tip of beak to posterior lateral border of alæ, 2·20; from tip of beak to posterior dorsal border of gular lamina, 2·37; from tip of beak to bottom of notch at its base, ·80; tip of beak to inner angle of gular lamina, 1·85; height of tooth from bottom of notch, ·25; breadth between teeth of opposite sides, ·60; from front to back of gular lamina, in middle, 1·75. The rostrum is black, with faint radiating striæ, and with slight undulations parallel with the posterior border; the beak is acute, slightly incurved, with a notch near the tip, from which a very evident groove runs back for a short distance, while a well marked, angular ridge starts from just below the notch, and descends in a curve to the ala, opposite the large tooth, defining a roughened or slightly corrugated and decidedly excavated area between it and the cutting edges; the cutting edge below this ridge is nearly straight, or slightly convex; the notch at its base is rounded and deep and strongly excavated at bottom; the tooth is broad, stout, obtusely rounded at summit, sloping abruptly on the side of the notch, and gradually to the alar edge. The anterior edge of the alæ, beyond the tooth, is rounded and strongly obliquely striated; it makes, with the cutting edge, an angle of about 110°. The inner surfaces of the two sides of the internal plate of the rostrum form an angle of about 45°.

The lower jaw of No. 1 (plate v, fig. 16) is represented only by its anterior part, the alæ and gular laminæ having been cut away by the person who removed it. It agrees very well in form and color with the corresponding parts of the one just described, but is somewhat smaller. The lateral ridges of the rostrum are rather more prominent, and the area within it is narrower and more deeply excavated, especially at the base of the notch, where the excavation goes considerably lower than the inner margin. The notch is narrower and not so much rounded at its bottom. The tooth is about the same in size as that of No. 10, and appears to be even more prominent, because the edge of the alæ is more concave at its outer base; it is also more compressed and less regularly rounded at summit. This jaw measures 1·30 inches from the tip to the posterior dorsal border of mentum; ·65 from tip to the bottom of the notch; ·16 from bottom of notch to tip of the tooth.

Both these lower jaws agree in having a very prominent tooth on the alar edge, with a large and deeply excavated notch between it and the cutting edge, and in this respect differ from the two lower jaws of *A. monachus* in my possession, for

in the latter the tooth or lobe is low and broad, and scarcely prominent, while the notch is narrow and shallow. This seems to be the best character for distinguishing the jaws of the two species. But they also differ in the angle between the alar edge and the cutting edge of the rostrum, especially of the lower jaw, for while in *A. monachus* this is hardly more than a right angle, in *A. princeps* it is about 110°. Moreover, the darker color and firmer texture of the jaws of the latter seem to be characteristic.

The proportions of the body seem to be quite different, if we can judge by the measurements given of the specimen (No. 1) which was found dead and floating at the surface of the water, at the Banks of Newfoundland, by Capt. Campbell, of the schooner B. D. Haskins, from Gloucester, Mass., in October, 1871.* It is stated that this specimen was measured, and that the body was 15 feet long and 4 feet and 8 inches in circumference. The arms were badly mutilated, but the portions remaining were estimated to be 9 or 10 feet long and about 22 inches in circumference, two being shorter than the others. This would indicate a much more elongated form of body than that of *A. monachus*. If these proportions be correct, the body of No. 10 must have been about 19 feet in length and 5 feet 9 inches in circumference.

This specimen is probably the largest invertebrate hitherto actually examined by any naturalist.

*Notes on specimens described by other writers.*—We are mainly indebted to Professor Steenstrup and to Dr. Harting for our knowledge of the specimens preserved in European museums, or cast ashore on the European coasts. Professor Steenstrup has given interesting accounts, compiled from contemporary documents, of a specimen taken in 1546, and of two specimens of huge cephalopods cast ashore at Iceland in 1639 and 1790, and has also described and figured† the jaws of another specimen of *A. monachus*, obtained at Jutland in 1853. In the same memoir, of which I have seen only the first part, there are references to a description and figures of *A. Titan*, obtained in 1855, by Capt. Hygom, in N. lat. 31°, W. long. 76°. The latter specimen appears to be the same that Harting ‡ mentioned, under the name of "*Architeuthis dux* Steenstrup," as collected at the same time and place, and of which he pub-

* See the American Naturalist, vol. vii, p. 91, Feb., 1873.

† In a paper of which I have only seen some proof-sheets, given by him to Dr. Packard, entitled "Spolia Atlantica." Whether this memoir has been published I do not know. The plate (I) that I have seen is marked "Vid. Selsk. Skrifter, V. Række, naturv. og mathem. Afd. iv Bind;" and there are references to three other plates illustrating *A. Titan*, etc.

‡ Description de quelques fragments de deux Céphalopodes gigantesques. Publiées par l'Académie Royale des Sciences à Amsterdam. 1860. 4to, with three plates.

lished an outline figure of the lower jaw, copied from a drawlng furnished to him by Steenstrup. Harting states that the pen or "gladius" of this specimen is six feet long. Many important parts of this specimen were secured, and I regret that I have been unable to see the figures and description of it, referred to by Harting as forming part of Prof. Steenstrup's memoir, then unpublished. But to judge by the outline figure given by Harting, it is a species quite distinct from those described above. The lower jaw resembles that of *A. monachus* more than *A. princeps*, and is a little larger than that of our No. 5. The beak is more rounded dorsally, less acute, and scarcely incurved, the notch is narrow, and the alar tooth is not prominent.

Harting, in the important memoir referred to, describes specimens of two species, both of which are evidently quite distinct from all those enumerated above.

The first of these (his plate I) is represented by the jaws and buccal mass, with the lingual dentition, and some detached suckers, preserved in the museum of the University of Utrecht, but from an unknown locality. These parts are well figured and described, and were referred to *Architeuthis dux* by Harting. But the character of the dentition (plate IV, fig. 8) is so totally different from what I have found in *A. monachus* that it will be necessary to refer this species to a different genus, if not to a distinct family. The form of the lower jaw is quite unlike that of *A. dux*, for the beak is very acute, the cutting edge is concave, the notch shallow and broad, and the alar tooth is somewhat prominent. The size is about the same as our No. 5. The suckers figured are from the sessile arms, and agree pretty nearly with those of *A. monachus*. The edge is strengthened by an oblique, strongly denticulated ring. The internal diameter of the largest of these suckers is ·75 of an inch; the external, 1·05 inches. They were furnished with slender pedicels, attached obliquely on one side. The lingual teeth (see fig. 8, copied from Harting) are in seven regular rows, and resemble closely those of *Loligo* (fig. 7). In fact, I cannot find, in the figures and description, any character by which this species can be separated from *Loligo*, and at the same time it is evident that it is a species distinct from all others known. I would, therefore, propose to designate it by the name of *Loligo Hartingii*.

The other species described by Harting was from the Indian Ocean, and belongs to the genus *Enoploteuthis*.

Mr. Kent, in the article already referred to,* mentions a sessile arm of a giant cephalopod, which has been long preserved in the British Museum, but of which the origin is

* Proceedings Zoological Society of London for 1874, p. 178.

unknown. He states that it is 9 feet long; 11 inches in circumference at the base, tapering off to a fine point. There are from 145 to 150 suckers, in two alternating rows, those at the base being half an inch in diameter. The relatively small size of the suckers and great length of the arms show that this arm cannot belong to the same species as our *Architeuthis monachus*, which Mr. Kent thought probable. But as the arms of *A. princeps* and *Loligo Hartingii* are still unknown, it might belong to one of those species; or it may belong to the species observed, but not captured, by the officers of the "Alecton," in 1861, near Teneriffe, and named *Loligo Bouyeri* by Crosse and Fischer, but known only from the imperfect descriptions of it given by the officers, and a sketch of it prepared while the crew were making unsuccessful attempts to get it on board.

The body of this one was estimated at 15 to 18 feet in length, with the arms somewhat shorter.

EXPLANATION OF PLATE.

Plate V.—Figure 14. Upper jaw of *Architeuthis princeps* V. (No. 10); natural size.
Figure 15. Lower jaw of the same. The dotted line shows the parts that are present on the opposite side.
Figure 16. Part of lower jaw of *Architeuthis princeps* (No. 1); natural size.

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ART. XXI.—*Contributions from the Sheffield Laboratory of Yale College.* No. XXXII.—*The Trap Rocks of the Connecticut Valley;* by GEORGE W. HAWES.

IT has been already stated in this Journal* that Mr. E. S. Dana and myself have been engaged in the study of the eruptive rocks of the Connecticut Valley. Some of the results obtained by me through chemical analysis are here presented.

The dikes which intersect the Mesozoic sandstone and the adjacent strata are very numerous and oftentimes very different both as to the physical appearance and composition of the rocks. The analyses of some of these traps show them to be nearly anhydrous and of the same composition as the rock which is called dolerite. They have, moreover, a bright and apparently unaltered appearance, and under the microscope a clear crystalline character. Others are hydrous and also contain carbonic acid; their luster is dull and they are more or less green, and possess the composition and the chloritic character of the rock called diabase. Every grade of variation between the extreme cases can be found; but the attempt will be made to show, by the following analyses, the

* See Abstract of a paper on the Trap Rocks of the Connecticut Valley, by E. S. Dana, this Journal, III, viii, 390. (Read before the American Association at the Hartford meeting, Aug., 1874.)

uniform character of the ejected material, and what were the changes which took place to alter it into its present varieties, and what were the causes of the same.

The specimens of which analyses are here given have in general been taken from railroad cuts or working quarries, in order to avoid material which had been altered by surface action.

### 1. Dolerite.

Lying to the west of New Haven there is a long ridge of trap, ending in a high bluff which is called West Rock. The trap is very firm, and analyses show it to be dolerite, the typical rock of this region.

West Rock. Sp. gr. = 3·03.

| | I. | II. | Mean. |
|---|---|---|---|
| Silica | 51·80 | 51·76 | 51·78 |
| Alumina | 14·21 | 14·19 | 14·20 |
| Ferrous oxide | 8·26 | 8·23 | 8·25 |
| Ferric oxide | 3·55 | 3·62 | 3·59 |
| Manganous oxide | ·42 | ·45 | ·44 |
| Lime | 10·68 | 10·73 | 10·70 |
| Magnesia | 7·63 | 7·64 | 7·63 |
| Soda | 2·15 | 2·13 | 2·14 |
| Potash | ·39 | ·38 | ·39 |
| Phosphoric acid | ·14 | ·14 | ·14 |
| Ignition | ·63 | ·64 | ·63 |
| | 99·86 | 99·91 | 99·89 |

West Rock is one of the southernmost dikes of the old Connecticut Valley. The red sandstone region extends northward through Connecticut to the northern boundary of Massachusetts, and in the latter State are Mount Tom and Mount Holyoke. A fresh specimen from the latter mountain had the following composition:

Mount Holyoke. Sp. gr. = 2·97.

| | I. | II. | Mean. |
|---|---|---|---|
| Silica | 52·70 | 52·65 | 52·68 |
| Alumina | 14·11 | 14·17 | 14·14 |
| Ferrous oxide | 9·78 | 9·80 | 9·79 |
| Ferric oxide | 1·87 | 2·03 | 1·95 |
| Manganous oxide | ·45 | ·44 | ·44 |
| Lime | 9·36 | 9·39 | 9·38 |
| Magnesia | 6·42 | 6·35 | 6·38 |
| Soda | 2·54 | 2·57 | 2·56 |
| Potash | ·89 | ·87 | ·87 |
| Ignition | 1·61 | 1·58 | 1·60 |
| | 99·73 | 99·85 | 99·79 |

These analyses show it to be dolerite, differing from the trap of West Rock in the proportion of its ingredients.

A specimen from the Mesozoic sandstone region of New Jersey, taken from a deep railroad cut in Jersey City, afforded the following results:

JERSEY CITY. Sp. gr. = 2·96.

| | I. | II. | Mean. |
|---|---|---|---|
| Silica | 53·16 | 53·09 | 53·13 |
| Alumina | 13·87 | 13·62 | 13·74 |
| Ferrous oxide | 9·09 | 9·10 | 9·10 |
| Ferric oxide | 1·01 | 1·14 | 1·08 |
| Manganous oxide | ·44 | ·43 | ·43 |
| Lime | 9·44 | 9·50 | 9·47 |
| Magnesia | 8·56 | 8·59 | 8·58 |
| Soda | 2·28 | 2·32 | 2·30 |
| Potash | 1·03 | 1·04 | 1·03 |
| Ignition | ·89 | ·91 | ·90 |
| | 99·77 | 99·74 | 99·76 |

Another specimen taken from a trap hill lying to the eastward of New Haven, called East Rock, was also analyzed. But enough has been given to show the uniform character of the unaltered rocks of this era; no two analyses differing from one another more than would those of samples which could be selected from the same dike.

The principal mineral ingredients are pyroxene and labradorite, with a small amount of magnetite, and often, as Mr. Dana has detected by his microscopic examinations, a little chrysolite and apatite. The *pyroxene* can be recognized by its cleavage. Spots are sometimes found in the rock where the crystals of pyroxene have considerable size, and often the prismatic angle as well as the basal cleavage can be distinctly seen. From one piece it was possible to extract a sufficient number of crystalline fragments of apparent purity for an analysis.

PYROXENE FROM WEST ROCK.

| | |
|---|---|
| Silica | 50·71 |
| Alumina | 3·55 |
| Ferrous oxide | 15·30 |
| Manganous oxide | ·81 |
| Lime | 13·35 |
| Magnesia | 13·63 |
| Ignition | 1·17 |
| Alkalies and loss (by difference) | 1·48 |
| | 100·00 |

On comparing this analysis with those of the dolerites, it leaves little doubt but that the feldspar is labradorite, as the

low percentage of silica and the presence of so much lime proves. The presence in one case of a feldspar with even a lower percentage of silica (see beyond) renders it improbable that the chief feldspar constituent has a higher percentage than labradorite. Moreover, in the analyses, making due allowance for the magnetite, the oxygen ratio of the bases and silica is even less than one to two, which would not be the case if the feldspar were oligoclase.

The *magnetite*, which is always present, is quite variable in amount. There is much more in the trap of West Rock than in any of the other specimens analyzed. This is evident from the amount of sesquioxide of iron present, which, if it be all contained in magnetite, would represent five per cent of that ingredient. In the Mt. Holyoke and New Jersey specimens there is less magnetite, as is shown by the lower percentage of sesquioxide of iron, the higher percentage of silica and the inferior specific gravities. In some cases the amount is very large. In a part of one of the dikes, that form the "Hanging Hills" of Meriden, the rock is quite black and the amount of iron has been the cause of rapid disintegration, so that now the fine earthy debris reaches to the top of the ridge. A determination of the iron in this rock gave

| | I. | II. |
|---|---|---|
| FeO | 8·52 | 8·55 |
| $Fe_2O_3$ | 5·30 | 5·35 |
| | 13·82 | 13·90 |

A few feet distant, however, the rock becomes as firm and undecomposed as usual, showing that the gathering of the magnetite was of no great extent. Often octahedral crystals of magnetite can be seen in the rock with the unaided eye.

The analysis of the pyroxene shows it to be ordinary augite containing equal amounts of lime and magnesia; and as magnesia does not enter into the composition of the feldspar, the evident excess of magnesia above that which would form such a mixture of labradorite and pyroxene belongs to the chrysolite. The minute crystals of apatite detected by Mr. Dana account for the presence of phosphoric acid.

The feldspar *anorthite* is sometimes a constituent of these dolerites. Passing up the West Rock ridge, at about a mile from its southern face, a smaller dike is seen with an eastern and western strike, while West Rock runs nearly north and south. This dike upon one side of West Rock forms the dam of Wintergreen Lake, then cuts directly through the main dike, and projecting out several yards upon the other side of West Rock ridge, forms what is called the buttress. Its position, intersecting the main dike, shows it to be of later origin. The direction of the columns of this buttress are hori-

zontal, while the columns of the main ridge are nearly vertical, which shows that the main ridge must have cooled sufficiently to determine the position of the columns of the buttress, since the columns are always at right angles to the cooling surfaces. This dike is characterized by large grains ($\frac{1}{4}$ to $\frac{1}{3}$ inch across) of a clear whitish cleavable mineral, which render it sparsely porphyritic. Even at the extremity, where the dike becomes very small, and where in consequence the rock is very fine in texture owing to the more rapid cooling, this porphyritic character is retained. A sufficient quantity of the pure material was extracted for an analysis; its composition was

ANORTHITE.

| | | O. |
|---|---|---|
| Silica | 45·95 | 24·50 |
| Alumina | 34·70 | 16·31 |
| Ferrous oxide | ·64 | |
| Lime | 15·82 | 5·06 |
| Magnesia | *trace* | |
| Potash | ·45 | |
| Soda | 1·80 | |
| Ignition | ·96 | |
| | 100·32 | |

It is therefore a lime feldspar; and the oxygen ratio for RO, $R_2O_3$ and $SiO_2$ is 1 : 3·2 : 4·8, which shows the feldspar to be anorthite. Mr. Dana informs me that under the microscope it has a different appearance from the other feldspar, and although triclinic it shows less tendency toward twinning. An analysis of a sample of the trap of the dike in which the anorthite occurs shows it to be a dolerite of the same composition as the others; which is proof of the uniformity of the ejections at different times in this period.

DOLERITE FROM WINTERGREEN LAKE. Sp. gr. = 3·00.

| | I. | II. | Mean. |
|---|---|---|---|
| Silica | 52·38 | 52·45 | 52·42 |
| Alumina | 14·59 | 14·50 | 14·54 |
| Ferrous oxide | 9·89 | 9·79 | 9·84 |
| Ferric oxide | 1·27 | 1·22 | 1·25 |
| Manganous oxide | ·50 | ·53 | ·51 |
| Lime | 10·63 | 10·54 | 10·59 |
| Magnesia | 7·36 | 7·31 | 7·33 |
| Soda | 2·20 | 2·27 | 2·23 |
| Potash | ·51 | ·48 | ·49 |
| Ignition | ·55 | ·55 | ·55 |
| | 99·88 | 99·64 | 99·75 |

The rock is therefore a mixture of pyroxene and labradorite, from which the anorthite crystallized out on account of its dif-

ferent composition; for a very slight change in the composition of the whole mass would account for the formation of the small amount of anorthite which the rock contains, and the difference in its fusibility, that of labradorite being 3, and that of anorthite 5, would favor the separation of the anorthite.

### 2. Diabase, or Chloritic Dolerite.

In the examination of the various dikes we find the rocks in all stages of alteration, from the almost anhydrous rocks, like the preceding, to those in which the original ingredients seem to have undergone an almost complete change. This difference we conclude to be connected with geographical location and not with geological age; and the following analysis, as well as the study of the positions of the different varieties, prove this.

The rocks which were selected for analysis were taken from the eastern side of the sandstone region and are typical specimens of very large and long dikes. The Lake Saltonstall ridge, which is hydrous through its whole extent, is cut through near its southern extremity by the Shore Line Railroad, and it was from this spot, at some distance from the surface and from any amygdaloidal cavities, that the sample was selected.

Lake Saltonstall. Sp. gr. = 2·86.

| | I. | II. | Mean. |
|---|---|---|---|
| Silica | 49·27 | 49·29 | 49·28 |
| Alumina | 15·87 | 15·97 | 15·92 |
| Ferrous oxide | 10·17 | 10·23 | 10·20 |
| Ferric oxide | 1·93 | 1·88 | 1·91 |
| Manganous oxide | ·35 | ·40 | ·37 |
| Lime | 7·46 | 7·42 | 7·44 |
| Magnesia | 5·90 | 6·07 | 5·99 |
| Soda | 3·45 | 3·36 | 3·40 |
| Potash | ·74 | ·69 | ·72 |
| Water | 3·92 | 3·88 | 3·90 |
| Carbonic acid | 1·12 | 1·17 | 1·14 |
| | 100·18 | 100·36 | 100·27 |

A specimen from the southern dike of a high ridge called the Durham Mountains exhibits still greater alteration, for the amount of water shows that the larger part of the pyroxene has been changed to chlorite.

It will be seen that the alteration of these rocks has not been attended by further oxidation of the iron, and therefore it could not have been accomplished by any surface action, since the oxidation of protoxide of iron is one of the chief causes of surface alteration; while in this case one mineral containing protoxide has been changed into another protoxide mineral. It would, therefore, seem certain that the alteration took place at

SOUTH DURHAM MOUNTAIN. Sp. gr. = 2·83.

| | I. | II. | Mean. |
|---|---|---|---|
| Silica | 46·56 | 46·51 | 46·54 |
| Alumina | 14·75 | 15·05 | 14·90 |
| Ferrous oxide | 9·89 | 9·78 | 9·83 |
| Ferric oxide | 3·58 | 3·50 | 3·54 |
| Manganous oxide | ·33 | ·35 | ·34 |
| Lime | 7·99 | 7·90 | 7·94 |
| Magnesia | 4·83 | 4·89 | 4·86 |
| Soda | 2·47 | 2·38 | 2·43 |
| Potash | ·59 | ·60 | ·60 |
| Water | 4·50 | 4·54 | 4·52 |
| Carbonic acid | 4·38 | 4·32 | 4·35 |
| | 99·87 | 99·82 | 99·85 |

the time of ejection, as has been urged by Prof. Dana.* If the trap-rocks of this eastern region, when coming up melted through the red sandstone strata, encountered subterranean waters, and if it would be impossible for the vapors produced by the heat to be pressed back, owing to the hydrostatic pressure above, then these vapors, together with other vaporizable material, as carbonic acid, set free from its combinations in the strata by the heat, would pass into the mass of molten matter. In this way we have a sufficient explanation of the change that made this diabase out of the material that formed the dolerite.

The pyroxene was the mineral that was most attacked, the result of the alteration being chlorite. As chlorite is a magnesian mineral, lime was set free by this change. Part or all of this lime united with carbonic acid; for on touching any of these hydrated rocks with a drop of dilute acid, effervescence takes place. In many of the amygdaloidal traps this carbonate of lime fills the cavities. The pyroxene, however, does not furnish sufficient alumina for chlorite; this was furnished by the feldspar, which also participated in the change, and which, under the microscope, appears more or less dimmed by decomposition. As a result, silica was liberated, which also fills many of the amygdaloid cavities; and often both silica and carbonate of lime are found in the same cavity. In other cases it has united with the lime and alkalies to form zeolites, which are common in the cavities. The exact chemical reactions that took place will be considered at another time, when more of the products of decomposition have been analyzed. That there was such a passage of vapors through the molten mass is evident; for the rock of some dikes contains long pipe-stem-like cavities, which were made by the ascending vapors, and which are generally filled with calcite.

* See this Jour., III, vi, 104. "J. D. Dana on Igneous Ejections and Volcanoes."

On excluding the water and carbonic acid from the two preceding analyses, (columns 3 and 4 below,) it will be seen how nearly the original unaltered material resembles that of the dolerites (columns 1 and 2) in composition. As usual, there is a small difference in the amount of magnetite and in the proportion between the pyroxene and feldspar.

| | 1. West Rock. | 2. Mt. Holyoke. | 3. L. Saltonstall. | 4. Durham Mt. |
|---|---|---|---|---|
| Silica | 52·11 | 53·54 | 51·90 | 51·06 |
| Alumina | 14·29 | 14·37 | 16·77 | 16·35 |
| Ferrous oxide | 8·30 | 9·95 | 10·74 | 10·79 |
| Ferric oxide | 3·61 | 1·98 | 2·00 | 3·88 |
| Manganous oxide | ·44 | ·45 | ·39 | ·39 |
| Lime | 10·77 | 9·53 | 7·83 | 8·72 |
| Magnesia | 7·67 | 6·49 | 6·31 | 5·33 |
| Soda | 2·15 | 2·60 | 3·59 | 2·66 |
| Potash | ·39 | ·88 | ·75 | ·66 |
| | 99·73 | 99·79 | 100·28 | 99·84 |

There is a remarkable uniformity at all points in the ejected material, which seems to prove that, whether now anhydrous or chloritic, it must have had a common source, and this a deep-seated one; for so great uniformity would be well nigh impossible if the source were nearer the surface among the metamorphic rocks of the crust, as has sometimes been supposed.

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ART. XXII.—*On the Comparison of Certain Theories of Solar Structure with Observation;* by S. P. LANGLEY. With a plate.

IN memoirs already published,* allusion has been made to the interest which would attend studies of the almost unknown interior of the umbra of sun-spots, and of forms there which, owing to the relative darkness, are hitherto nearly undescribed, and reference has also been made to certain so-called "crystalline" shapes seen at times, and which are especially associated with large spots and periods of great disturbance.

Doubtless owing to the difficulty of seeing appearances so delicate, these "crystalline" types have never been minutely delineated, and it has been naturally assumed that their existence lent some confirmation to the views of those who regard the photosphere as the luminous covering of an incandescent fluid, and consider spots as deposits of cooling matter, more or less analogous to the scoria deposits of terrestrial volcanoes. M. E. Gautier has, in a very interesting communication to M. Faye,†

* American Journal of Science, February, 1874. Royal Astronomical Society's Notices, March, 1874.

† Comptes Rendus, May 18, 1874.

referred to these forms, and to my description of them. They are indeed so remarkable, and at first sight so apparently confirmatory of the views alluded to, that only after long study I have been led to think them not so much assimilable to the products of cooling upon a liquid surface as to certain cloud forms of our own atmosphere.

To furnish material for a public examination of these details, whose study is so eminently instructive, it is necessary, as has been already remarked, (since photography cannot yet seize them,) to make drawings in which the single aim of the designer is to set down with a minute fidelity specific forms; aiming, in short, much more to produce a piece of accurate topography than a picture; but while it is on studies made of this minute exactness that discussion will be most profitable, their reproduction for the press is a work of so much labor that this kind of illustration will probably remain unusual.

The steel engraving, plate VI, from studies made at the Allegheny Observatory chiefly with the full aperture (13 English inches) of its equatorial, has been prepared by the kind furtherance of Prof. George F. Barker, of Philadelphia, its execution being secured at the hands of an engraver who has done his work with peculiar fidelity and skill. I trust it will be accepted as a means of putting the reader in a certain sense in the place of the observer, and enabling him himself to directly compare theory with the facts of observation. This plate is made from sketches taken on the 23d, 24th and 25th of December, 1873, of the eastern extremity of the great spot then nearing the center of the sun, and about 12° south of the solar equator. It is called a "typical spot" because (since the details could not be completed at a sitting) it is less an accurate outline of what could be seen at any one moment, than an assemblage of the different types presented, in their proper connection. The whole, then, is taken from observation; but while the details of the adjacent photosphere have been supplemented from other studies, everything in the main body of the spot is the most literal transcript I could make of specific penumbral and umbral forms.

The sun had been hidden here for some days before the 23d of December, when the sky cleared, disclosing a spot of more than usual size. Although a daily record of the solar surface is maintained at the Allegheny Observatory, the weather for some weeks before had interrupted it so capriciously that I am unable to say with certainty what the age of the spot was when it suddenly presented itself, but unquestionably it had at this time already passed through the initiatory stage of its formation, and had entered upon that in which the forms seen earlier have commenced to become segmented or distorted, while still

retaining characteristics which show the type from which they have sprung.

Attention was first directed to that dark interior, in which Dawes discerned still darker shades, which he called *nuclei*, as the unusual size of the spot and the irregularity of shade in the umbra seemed to favor their investigation. Aided by special optical devices, there became visible to close attention, forms which appeared to be affiliated to the better known ones of the penumbra, which were studied also, and a description of a part of whose characteristics, interesting perhaps in their bearing upon solar theories, follows.

It was observed: (1.) That the now well-known filaments of the penumbra, and those (still to be described) of the umbra, were all disposed in curves. These curves might be described in general as portions of rude spirals, since while there was such a variety as to make classification difficult, the spiral type was, as a whole, beyond any question the dominant one. This and the characteristic forms of the outer penumbral edge, elsewhere partly described, bear witness to the existence of a force, or perhaps I should say the component of a force, directed in a general sense to the center of the spot, while at the same time the absence of a common direction of rotation, and the existence even of distinctly marked opposite flexures in the same filaments, show the complexity of the action which had been at work.

(2.) An appearance which deserves remark is this. It has long since been observed that the interior border of the penumbra is commonly brighter than its exterior; but the hitherto unrecognised cause is here shown, in a general tendency of these singular objects, the filaments, to grow progressively brighter toward their extremities. It should be noticed that it is not only here meant that these grow brighter at the inner edge of the penumbra, but that the many filaments, not long enough to reach wholly across the penumbra, and whose ends in this case lie partly down its slope, in every case show the same tendency, so that it is difficult to resist the impression that these extremities have a general disposition to turn upward and to appear as though lifting their points above some obscuring medium.

(3.) In this connection we may best study the umbral forms previously referred to, about which so little has hitherto been known, owing to the darkness in which they are involved. That this darkness is only relative has been long surmised, and I have found by direct experiment that when all extraneous light is excluded, except that from the "blackest" part of the umbra, this proved to be not only intrinsically bright, but insupportably intense to the naked eye. By the optical device referred to, then, I have been able to look within the sun to some limited

extent, or farther at least below the surface than is commonly seen. Thus armed, we find that the reddish-brown masses within the umbra are resolved into filaments, analogous to the penumbral ones; like them disposed in curves, and like them apparently in planes, whose direction is usually approximately horizontal. Here also we see that these umbral filaments grow brighter toward their extremities, which *appear* as if curling upward, their ends thus occasionally furnishing that appearance of isolated bright points in the umbra which has been already observed.

Leaving these for the moment, let us consider what was, on the whole, the most remarkable feature of the spot: a plume-like appearance in its lower portion,* which, in connection with adjacent peculiar curves, presented forms of what has been called the "crystalline" type. The impression that agencies like those which mould the delicate crystallizations of water have been here engaged, is a natural one, and has been expressed before, the term "photospheric crystal" having apparently been used by M. Chacornac as long ago as 1853. This part of the spot, if any, would seem to justify the remark of M. Gautier, that the modifications of certain spot forms recall rather the effects of mineral or saline deposits than that of the action of whirlwinds. They may certainly be said to remind us of such deposits, but is it by a true analogy or by a superficial resemblance? If we look closer; if we increase our telescopic power, we find that filaments which elsewhere possess a scarcely sensible magnitude become here of immeasurable fineness, and lie, not so much at the sharp angles of a crystalline deposit, (as they with lower powers seem to do,) as like finely carded wool. We may be in doubt whether to treat these "plumes" as part of the penumbral or umbral structures, their brightness seeming to affiliate them to the former, while, on minute examination, their fibers may yet be discerned prolonged through the umbral shade and rising again (apparently) above it, in the luminous points just referred to. The resemblance seen here, then, is rather to the filamentary types found in the chromosphere, and which no one questions are purely gaseous. There is frequently remarkable symmetry displayed in these forms, but very rarely as much as in the present example, which was the most regular I have ever seen. The balance of its parts around a central axis was almost as exact as in a sculptured ornament, and here again the regularity of certain crystalline forms is suggested. The "plume," however, whatever it may be, is evidently an integral structure, not due to the casual union of heterogeneous elements, and it was found on measurement to be approximately 20″ in length and 10″ to 12″ in

* Seen in the lower portion of the drawing.

width. Are we prepared to admit the existence of a body properly analogous to a "crystal," covering over ten times the area of Europe? Even on the sun, where everything is enormous, this taxes belief. But once more, the extremely attenuated filaments of the "plume" do not appear to be in any single plane. The great length of nearly 10,000 English miles, through which they apparently extend, is a curtate distance, or that in which we see them as projected on the apparent plane of the solar disc. If I do not misinterpret the indications given by the brightening ends, they can hardly be spread upon the surface of a liquid, or upon any single surface whatever,—they bend *down* and *up*. All through the umbra are to be noted similar appearances; we seem to look down through increasing depths, but as far as vision extends, without coming to any liquid or solid floor,—always down through volumes of whirling vapor, (whirling, if we judge from their forms, which are disposed as if by vortical action,) and growing fainter till lost to sight at an unknown depth below the surface. Speaking, then, without reference to any hypothesis, it seems to me that the resemblance to crystalline structure (though I agree that it is striking) does not appear to be more than superficial. We have at certain rare intervals remarkable cirrous clouds in our own atmosphere, whose resemblance to these forms is equally close, and in which, I think, we may see not only a resemblance but an analogy. Some of these rarer cirrous types of our own sky, which I have studied in connection with solar forms, might, so far as external appearance went, certainly be fancied to display crystalline action as clearly as any frost-figure on a window, yet we have no difficulty in seeing that in this case the eddies of our own atmosphere have been in some way a principal cause. While recognizing the danger of pushing too far, conclusions drawn from terrestrial analogy, I should then (pending a more complete study of these appearances), regard them as most nearly typified by certain cloud-forms of our own atmosphere.

This spot presented other interesting types not here referred to. But I may mention, in support of previous observations, that in the upper portion of the penumbra, just below where a considerable part of the photosphere was islanded, the sudden and abrupt change of direction of the filaments marked the apparently unmistakable passage of one cloud stratum over another. This disposition was also marked elsewhere on the spot, whole banks of clouds moving one over the other, so as to form a *terraced* appearance. In very many other spots, this movement of one stratum over and frequently at right angles to another has been recognized, so that after long study, I have felt justified in elsewhere formally announcing it as an ascertained fact,

observed not in an isolated instance, but as a general characteristic of the solar surface, whose features are thus again assimilated to atmospheric ones in some degree like our own.

From the preceding facts of observation, it appears that the following conclusions may be drawn:

(1.) Without prejudice to the important considerations on which its distinguished author has framed the theory of the existence of a liquid or viscous solar shell, it seems to me, speaking simply as an observer, that, from what has been stated of the appearance of umbral forms, such a shell or crust must, if it exist, be at a distance, below the surface of the photosphere, considerable even with reference to the dimensions we here deal with.

(2.) It seems difficult to reconcile the bright, sharply-defined inner penumbral edge, and the regular structure discerned in the umbra, with another view, in which this umbra is a sort of stagnant pool, formed by cold vapors, or clouds, which have settled there after depressing the general surface by their weight till the penumbral slope is determined. So much of the early hypothesis of Herschel as regards the umbra as an opening (however made) *through* which we look into a non-luminous interior of the sun, extending everywhere beneath the photosphere, seems common to views which, differing widely elsewhere, agree on this point more nearly with these observations than with the views peculiar to Father Secchi.*

(3.) Finally, it seems to be little more than a summary of the facts of observation already rehearsed, to say that traces of a vortical action are found throughout the spot, and especially in the umbra. The theory which regards cyclonic or vortical action as a prominent agent in determining the forms we have studied, appears then to be in closer accordance with observation than the former.

As the substance of the present article was written before Father Secchi's remarks appeared in the August *Memorie*, it was originally prepared without reference to the questions raised there, and without any special reference to the cyclonic theory; and it is in no sense meant as a complete expression of opinion on those several points, in connection with which Father Secchi has done me the honor to cite my name. As one of the few who have used an instrument of adequate power in the particular field of research in which a large part of his labors have lain, I am more able than most, perhaps, to appreciate his eminent qualities as an observer. When, however, he states that longer study of the sun than I have yet given, will

* . . . "Il solo errore dell 'illustre osservatore (i. e., Herschel) fu di estendere la massa oscura su tutto il globo sotto la fotosfera, *mentre in realtà essa non forma che pezze o chiazze assai limitate.*—*P. Secchi, Memorie, Agosto,* 1874.

change my views upon the theory of M. Faye, I may remark that those views were not emitted so hastily, or on such light grounds, as to be readily altered; for they were the result of several years of observation, with an instrument of greater power than that Father Secchi employs. Doubtless, before adopting conclusions in any way differing from those reached by one whose ability as an observer deserves such respect, I was bound in every way to verify the grounds on which these conclusions rested. If what seem to me the facts of observation conducted, and still continue to conduct me, to views in many ways differing from those which he maintains, in opposition to distinguished Italian and French astronomers, I have less hesitation in trusting to observations which agree more nearly with theirs, from the belief that no personally cherished hypothesis has subjected me to that unconscious bias in the collection and interpretation of facts, against which common experience shows that even eminent ability is not a certain protection.

Allegheny Observatory, Allegheny, Pennsylvania, December 29, 1874.

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ART. XXIII.—*Notes on Costa Rica Geology;* by W. M. GABB.

SINCE the beginning of 1873, I have been engaged in an exploration of the southeastern corner of the republic of Costa Rica, a region of about 3,000 square miles, known politically as the District of Talamanca. Previous to my going there, the country was probably the least known of any part of Central or Isthmian America. It comprises the Atlantic slope of nearly one half of the length of the republic, and is inhabited by tribes of Indians who, with good reason, have such a hatred to everything called Spanish, that the people of the country have never dared to penetrate it. Strange to say, the hatred is not against the white race; only against "Spaniards," i. e., persons of that race, or speaking that language. A few English-speaking traders have had dealings with these people for half a century, and have invariably treated them well; so that an Englishman or American can go among them with impunity; while one speaking only Spanish is looked upon with distrust, and either treated with insolence, or at best left severely alone.

I was at first engaged by a company of the leading persons in Costa Rica, natives and foreigners, but afterward the Government took charge and assumed the responsibility of the work. The prime object of the exploration was the re-discovery of some mines, reported by tradition to exist in the region, and of which the most fabulous stories were told. Suffice it here to

say that such mines do not, and for sufficient geological reasons cannot, exist there. This, however, is not surprising to one who has been in California or in the West Indies, where such traditions exist everywhere. Having now completed the field-work of this little isolated region, I consider it advisable to put on permanent record a bare *resumé* of the leading facts and observations, leaving all theories and deductions for a future occasion. It is difficult, and perhaps unadvisable, to attempt to generalize where one's observations have been so entirely circumscribed as mine have been in this district. I have not been able to carry my observations to the Pacific; and the conglomerate rocks, of which I shall speak, point to older sedimentary formations which I have not seen, and which may have played an important part in the history of Isthmian America.

The central Cordillera of the lower part of Costa Rica is not much less than 6,000 feet high at its lowest point. Along this crest rise several prominent peaks, that of U-jum, at the head of the Coen River, and Mt. Lyon, at the head of the Lari, being probably over 8,000 feet each, while Pico Blanco, or Kamuk, the culminating point, is 9,652 feet, by careful barometrical measurement. Farther down the isthmus the reputed volcanoes of Chiriqui and Robalo are said to be of corresponding heights; but to the northwest a decided depression of the range occurs, before we reach the high region of Central Costa Rica. The direct distance from the summits of the range to the coast is hardly more than thirty miles; but the country is so cut up by sharp ridges and deep cañons, so covered with dense forests and impassable swamps, and so poorly supplied even with Indian trails, that the distance travelled is fully three times as great. In an open country, with good routes of travel, I could easily have accomplished in three or four months all the geological explorations that necessitated seventeen months of the hardest labor I ever did in my life. This is not the place to speak of toil and suffering, of exposure for weeks to continued rains, of fording swollen rivers at the risk of our lives, of fevers; in short, of all the pleasant episodes inevitably connected with work in primeval tropical forests. We have been through them all, and without the loss of a single life in my corps; albeit, several Indians paid that penalty, and, although I escaped with health uninjured, some of my assistants have been less fortunate in this respect.

The chain slopes rapidly to the northeast, and in a dozen miles from the summit is barely more than a thousand feet high. The next dozen miles is a still more gentle slope; and the coast is bordered by a flat region of swamp, broken by only a few low spurs.

Two large rivers drain the region. These are the Tiliri (sometimes called the Sicsola) and the Tilorio (likewise known at its mouth as the Changinola). These names in parenthesis were given by the Mosquito negroes to the mouths of the rivers, and, although they occur on the maps, are not the real names of the streams. The Tiliri is the more important of the two, draining by far the larger area, by means of five great branches, viz., the Tiliri proper, the Coen, the Lari, the Uren, and the Zhorquin. All of these branches, except the last, unite, in the space of a mile, in a broad valley of over 100 square miles of area. The Zhorquin is the smallest branch, does not descend from the main range, as the others do, and enters the Tiliri a few miles below the junction of the other branches.

The Tilorio drains the region east of Pico Blanco, by one great arm and its branches, and the country back of Pico Robalo, by another arm. This latter is entirely unknown, and is likely to remain so, until some traveller more adventurous than any yet found dares to penetrate the region. The Indians reported the country to be almost impassable, and say it is inhabited by a small band of Indians who refuse unconditionally to hold any communication with civilized people, or to permit them to enter their district. Several such refugee bands of savages are known to exist in this vicinity, and I have little doubt but that there is good foundation for the story.

The high mountains of Talamanca are in great part made up of a mass of granitic rocks, bearing in some respects a marked resemblance to those of the island of Santo Domingo. There is one important point of difference, however, between the manner of occurrence of this rock here and in Santo Domingo. In the latter country, granitic dikes often cut through or extend into the sedimentary rocks for great distances. They are of all sizes, from a thread to hundreds of yards in thickness, and often contain fragments of the jaspery slates entangled in them, and perfectly soldered by fusion. In Costa Rica I have never seen a granitic dike. The material seems to have been forced up from below in a plastic state, sufficiently heated to have changed the character of the overlying rock wherever it came in contact with it, but never sufficiently fluid to penetrate any possible fissures that may have existed. True granite rarely occurs, while syenites are much more common. The rock is almost always rather fine-grained, and while hornblende abounds, mica is rather the exception than the rule. The rock is lighter in color, and of a slightly coarser grain at the more eastern exposures than farther west. I saw nowhere the slightest approach to a gneissoid structure, or any other sign that would indicate a metamorphic origin for the mass, but several facts point to its having been quite recently in a heated condi-

tion. On the upper part of the Coen River, on one of its largest western branches, I found a single small boulder of mica slate, but I could not trace it to its source.

Lying on the flanks of the granite, in the region of the Tiliri, and extending to the coast, there is a deposit, only a few hundred feet thick, of Tertiary rocks, where, in contact with the granite, they are highly tilted, dipping seaward; a large fold or two follows this uplift in the higher mountains, and more gentle undulations extend to the coast. There is not a regular system of plications, however, since I have observed local variations of strike, even as great as at right angles, within a mile, accompanied by high dips. This is markedly the case on the Zhorquin, near its mouth, where, perhaps, the underlying granite is not far below the surface. Close to the granites the sedimentary rocks are highly metamorphosed, and in most cases their bedding is entirely destroyed; but I was fortunately able to collect fossils at a number of localities scattered not only over the greater part of Talamanca, but also farther north and northwest, in the adjoining parts of Costa Rica. These prove, beyond a reasonable doubt, that the rocks are an extension of the great Miocene deposit found not only on the isthmus proper, but over so many of the West Indian islands. I recognized at sight many familiar species, and have no doubt that others only await comparison to identify them with known species.

These Miocene rocks are made up principally of conglomerates and fine shales, with occasional beds of sandstone, and a very little limestone. The limestone occurs most abundantly in the central regions of Costa Rica, in the Candelaria Mountains, and on the Reventazon River near Sapote, and are almost entirely wanting in Talamanca. The conglomerates and shales are also found as far as the latter locality; while the last mentioned rock is the most important constituent of the Candelaria range. Wherever the shales are found unaltered, they carry small beds of very inferior coal. It is to this member that the coal mines of Chiriqui belong; and, half a dozen miles south of San José, the capital of Costa Rica, there is a small mine of coal now being worked experimentally, with results far from encouraging.

The conglomerates are made up entirely of pebbles of a metamorphosed claystone. I have studied them with great care at almost every locality where I found exposures, and have never met with a single boulder or pebble of crystalline material. Even where close to the granitic rocks, I failed completely to find the slightest trace of granite. Nor have I been able to trace to their source these claystone pebbles. The formation must have been extensive to have furnished such a bulk of coarse mate-

rial, to say nothing of the shales probably derived from the same source. The absence of granite pebbles proves conclusively that this rock was not exposed at the time of the deposition of the Miocene. Another peculiarity of the conglomerate is that, while from the region of the Tiliri west and north, as far as the line of the railroad now being constructed, the pebbles are hard and well rounded by attrition, and cemented by a matrix of different character, on the Tilorio the rock is rather a mottled claystone than a true conglomerate. The pebbles seem to have been but little altered, to have been imbedded in a matrix formed from their own material, disintegrated, and the whole, after deposition, to have undergone metamorphism together for the first time.

The trend of the granitic intrusion is not coincident nor coextensive with the mountain range. It bears more to the east, Pico Blanco being its culminating point: beyond this to the east it extends almost to the Tilorio River, ending in a narrow tongue. I was unable to ascend the Tilorio, back to the granite belt; but although there are large streams penetrating westward from the Tilorio toward Pico Blanco, there are no granite boulders in that river on its head waters.

Both the granite and the Miocene rocks are cut by numerous porphyritic dikes of a pretty uniform character, but entirely different from the more modern volcanic rocks of Central Costa Rica. These seem to have penetrated the two groups equally, and vary from a few yards to a mile in length. One of these dikes forms the apex of Pico Blanco, and has been exposed by the decomposition and denudation of the surrounding softer granite. This is nearly 300 feet high, and forms the extreme tip of what is otherwise an ordinary granite mountain. Space does not permit me to enter into a detailed discussion of this question here. I was three hours on the summit of the mountain. It is a simple, straight ridge, of which the western end rises in a sharp cone, perhaps fifty feet higher than the rest. There is no sign whatever of a crater, and 300 feet below the summit there is no volcanic rock. It must, therefore, be struck from the list of volcanoes.

The two neighboring peaks, Mt. Lyon, between the Lari and its branch, the Dipari, and U-jum, at the head of the Coen, are said by the Indians to be volcanoes. But after my experience with Blanco, I feel great hesitation in accepting the statement, although it is fortified by many very plausible stories of fires and smoke seen on their summits. The latter, especially, with its sharp, regular cone, certainly looks volcanic, and I had hoped to reach it; but after my excursion to Pico Blanco, all hands of my party, white as well as Indians, decided that for the time, at least, it was impracticable. It would have cost a

month of hard work, and I had not so much time at my disposal.

Before closing my account of the mountain region, there is one other item deserving mention. My instructions required me to look for mines, and I examined carefully for traces of the precious metals wherever I went. I found in a few places quartz veins; one of considerable size, the others practically valueless. I also found deposits of placer gold in a few localities. But the existence of gold here is rather of scientific than of economic interest. The gold occurs in the metamorphosed Miocene rocks, and always at a greater or less distance from the granites. The point at which I found gold nearest to the granite was at least a mile distant, although the rock was highly metamorphosed. The spot where I found the largest quantity of gold was miles away from the granitic intrusion.

There is little more to be said about the geology of Talamanca. The coast is low and swampy, and is bordered by a few patches of Post-pliocene rocks of the character which I have designated as Antillite in the West Indies. Near Moen, back of the border reef, there was a little bay, where a dark gray claystone was deposited, and this bed, nearly 100 feet thick in one place, abounds in beautiful fossils, all of recent species of shells and Radiates. Many of the Mollusca retain their colors quite bright. On the beach, at some points, are large deposits of iron sand of great purity, which might be utilized.

To my great regret, I have not been able to carry my section completely across Terraba to the Pacific. On the summit of Pico Blanco, after robbing Irazu of its boast that it was the only point whence both oceans can be seen at the same time, we could only look over Terraba and wish. The granite was pushed up after the deposition of the Miocene. This I have demonstrated by the absence of granitic pebbles in the conglomerate. It therefore seems probable to me, *à priori* (I admit a not perfectly safe argument), that the same formation extended across; and standing on the peak, and looking at the hills and plains on both sides, I could not but feel convinced that on the south base of the mountain I must find the same rock as on the north. Add to this, that but a few miles farther east the rock does actually run around the end of the granite, there seems good reason for expecting to find the plains of Terraba to be Tertiary. Further, as far north and northwest as I have traced sedimentary rocks, they are of the same age, as proven by fossils. The whole Atlantic slope of Costa Rica may be safely predicted to be Miocene.

Above Moen are broad, flat plains, which sweep around to the bases of the volcanic peaks of Turrialba and Irazu, and the

farther north I followed the Miocene the less disturbed I found it. East of the volcano of Turrialba I found Miocene, with abundance of characteristic fossils, but little tilted, and in one place actually horizontal. Sweeping round to the westward, the Candelaria range is made up of the same rock, here somewhat disturbed, but with a general strike corresponding to the trend of the range. Beyond this everything is covered with great beds of volcanic ash and cut up by innumerable dikes of volcanic rock. North of the valley the magnificent line of volcanoes, Turrialba, Irazu, Barba, and Poos covers all the other rocks; but on the west face of the Aguacate Mountains, where the coating of ash is in places absent, we find highly altered claystones. These are rich in mineral veins, and have been thoroughly explored for mines of gold and silver. Whether the rock is the ancient clay slate from which the conglomerates were formed, or whether it is highly metamorphosed Tertiary, we have, as yet, no means of knowing, and the problem will require careful study for its solution.

Costa Rica, Nov. 29, 1874.

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ART. XXIV.—*Note on the Discovery of a new locality of Primordial Fossils in Rensselaer County, N. Y.;* by S. W. FORD.

SEVERAL weeks ago, in company with my friend Mr. James C. Bell, Jr., of this city, I visited the hills a short distance to the east of the village of Lansingburgh, for the purpose of examining more minutely than I had previously done the interesting series of rocks there exposed. The strata first met with in going eastward from the village consist, in ascending order, as follows: (1) a series of thin-bedded gray sandstones with slight shaly partings; (2) a series of fine black slates and shales alternating with thin sandstone layers of a pinkish color, the surfaces of which are frequently profusely covered with ripple-marks and worm-burrows; and (3) a deposit of heavy-bedded gray sandstone with fractures running in every direction, and with now and then thin shaly seams which serve to indicate the bedding: the surfaces of the fractures, with few exceptions, thickly studded with small crystals of quartz. The thickness of the above enumerated beds cannot here be given with exactness; but that of the thin sandstones is not far from thirty feet, and that of the superposed slates and shales about twenty. The heavy-bedded sandstones are of much greater extent. At one point they form a sharp, bold elevation, locally known as "Diamond Rock." All of these beds are arranged in a series of close synclinal and anticlinal folds,

leaning to the northwest; and, as a result of this arrangement, the rocks of this region have a nearly uniform southeasterly dip. I was unable to obtain any fossils in these rocks, but at a locality about half a mile eastward of the first exposures examined I was more successful. At this point an apparently higher series of slates is met with, and these are, in turn, succeeded by a considerable deposit of conglomerate limestone. This latter rock is a most singular formation, appearing as if composed of innumerable blocks and wedges of limestone confusedly thrown down and afterward firmly cemented together. It appears almost incredible, at first sight, that fossils should occur in such a looking mass. But in a detached block of limestone lying only a short distance from the deposit in question, and to which I am satisfied it belongs, I found upward of half a dozen imperfect heads, and three perfect specimens of what I consider to be the pygidium of *Conocephalites* (*Atops*) *trilineatus* Emm. In addition to these I obtained from the main mass an unequivocal specimen of *Hyolithes Americanus* Billings; and on examining, on my return home, a piece also broken from the rock *in situ* by Mr. Bell, I found a specimen of the species described by me under the name of *Obolella nitida*. All of these species likewise occur in the Lower Potsdam limestones at Troy. No perfect specimens of the pygidium of *C. trilineatus* have, to my knowledge, hitherto been found; and while reserving the complete description of it till another time, I will refer to its leading characters here. It is nearly semicircular in form, the axis strong, composed of seven segments, with a row of obtuse spines along the middle; lateral lobes composed of five segments each, with distinct intervening grooves; marginal-rim nearly flat, widest toward the front, and distinctly and regularly notched or denticulated all around.* The surface of the border is finely granular. On page 405 of his "Palæozoic Fossils," vol. i, Mr Billings has figured the pygidium of a trilobite from the Quebec group, which has the marginal-rim notched in precisely the same manner as that of *C. trilineatus*. Mr. Billings does not refer it positively to any genus. On comparing the characters furnished by the figure with those of the pygidium of *C. trilineatus*, I strongly suspect that the form in question belongs to the genus *Conocephalites*. At present, it appears to me quite probable that it is the tail piece of *Conocephalites Zenkeri*, described on page 398 of Mr. Billings' work cited.

* In the configuration of the border above noticed, this species differs widely from any species of the genus hitherto described. Barrande, in his beautiful work on the Trilobites, places the genus *Conocephalites* in his group of genera in which the border of the pygidium is unbroken or entire (Systême Silurian de la Bohême, vol. i, p. 220). The species known as *Conocephalites Iowensis*, from the Wisconsin Primordial, furnishes another exception to the rule. In that species the border of the pygidium is prolonged backward into two long diverging spines. (16th Reg. Rep.)

I regard the Lansingburgh limerock as the stratigraphical equivalent of my limestone band No. 1, at Troy. (See this Journal for August, 1873.) They are lithologically similar; and, moreover, have furnished two species in common, namely, *C. trilineatus* and *Hyolithes Americanus.* At Troy this deposit is similarly underlaid by a heavy slate formation, while apparently below this, and in the same line of outcrop, there are exposed at one point a few layers of thick-bedded sandstone similar to that constituting "Diamond Rock." The inferior slates and thin-bedded sandstones of the Lansingburgh section are, so far as direct observation goes, here wanting; but, if I am right in my interpretations, they are most probably present, but are not brought up to view. The equivalency of the Troy and Lansingburgh beds cannot be proved by actual inspection of the rocks between these two places, since, for the greater portion of the distance, there are almost no exposures. In my first regular paper relating to the rocks of this district (this Journal, July, 1871), I briefly referred to the Lansingburgh slates and sandstones described at the opening of the present article, and spoke of them as most probably an inferior division of the Lower Potsdam. This provisional reference was based alone upon the stratigraphical evidence I then possessed, as the accompanying limerock had at that time yielded no positive testimony bearing upon the subject. The evidence now in hand seems to sustain the correctness of that reference, but it is quite possible that these lower sandstones may yet be found to contain a still more ancient fauna. I hope in the coming spring, if my opportunities permit, to give this field a more careful and extended study.

Troy, N. Y., Dec. 26th, 1874.

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ART. XXV.—*Abstract of a Memoir on the Origin, and Mechanism of Production, of the Prismatic or Columnar Structure of Basalt;* by ROBERT MALLET, F.R.S. (Read before the Royal Society, January 21st, 1875.)*

THE author, having briefly traced the history of geological opinion on this subject from before the period when the controversy in which the igneous or aqueous origin of basalt may be viewed as settled, and having stated the views of some of the more prominent British authors of recent date on this subject, points out that, up to the present, no clear and definite theoretic views have been enunciated to account for the prismatic structure in basalt, and that it is impossible to gather, with

* We are indebted to the author for this abstract.—EDS.

any distinctness, from systematic writers, whether prismatic structure be due to contraction by cooling alone, or whether the structure is due to preëxisting concretionary or crystalline arrangement of the integral particles of the mass, or to this coacting with enormous external pressures, the origin of which is left perfectly vague, or to some play of successive and joint actions of all these various forces.

Professor James Thomson, in a paper read some years ago, and since repeated at the Belfast Meeting of the British Association, has proposed views in some respects new, tracing prismatic structure to contraction by cooling only, and has expressed entire doubt as to the part supposed to be played by concretionary spheroids pressed together. Professor Thomson's views, however, are still far from complete, and the mode assigned by him to the production of cup-shaped cross joints in the prisms fails to account for the phenomena.

The aim of the author is to point out in this paper that all the salient phenomena of the prismatic and jointed structure of basalt, as observable in nature, can be accounted for upon the admitted laws of cooling, and contraction thereby, of melted rock possessing the known properties of basalt, the essential conditions being a very general homogeneity in the mass cooling, and that the cooling shall take place slowly, principally from one or more of its surfaces.

Thus, taking the simple case of a tabular mass of molten basalt, whose top surface is level, the depth being great, and the two other dimensions indefinitely greater than that, and assuming the material at one temperature initially, and homogeneous and isotropic, and that cooling takes place from the top surface only, he, on these data, proceeds to consider the phenomena that will successively result by contraction in cooling.

While the mass remains at its upper part still plastic by heat, contraction will be met by internal movements and subsidence of the top surface, and no cracking or splitting can take place until the material there has become rigid enough to break under tensile strain. He points out that this degree of rigidity, or "splitting temperature," is not reached until the top surface has fallen to between 900° and 600° Fahr.

At this temperature the cooling surface begins to separate by fracture, penetrating perpendicularly to it into smaller surfaces. These must be similar and equal in area, and such that their edges in contact can make up a continuous superficies. To relieve the orthogonal strains in the cooling surface, and to meet the above conditions, only three geometric figures for the separating surfaces are possible, namely, the equilateral triangle, the square, and the regular hexagon.

The author then inquires why the last of these is normally the force found in nature. He traces this to the law of least action which governs the play of all natural forces whose final result is produced by the least possible expenditure of force. He shows that, in a contracting surface splitting up into equal areas, the expenditure of work will, for the equilateral triangle, the square, and the regular hexagon, be approximately as the numbers 1·000, 0·680, and 0·519. This economy of force decides the hexagon as the form found in nature. The diameter of the hexagon, which is the upper surface of the inceptive hexagonal prism, is shown to be fixed by the relation that subsists between the coefficient of contraction and that of its extension at rupture by a tensile force at the splitting temperature. This decides the diameters of the separate prisms. The splitting by contraction proceeds into the mass always in a direction perpendicular to the cooling surface, and at any instant the splitting is limited in its progress by the isothermal *couche*, which is at the splitting temperature within the mass; for within that *couche* the mass is still plastic. In the case assumed the prisms formed are straight and vertical. When the splitting has proceeded to some distance within the mass, the further cooling of each prism takes place not only from the top, but from the sides, and the more important conditions influencing the latter in nature are pointed out.

Any one prism is coldest at its extremity, and its temperature increases along its length to the other end, where the splitting is still proceeding. The prism is hotter, also, for any transverse section, as we approach its axis, than about the exterior; differential strains in the longitudinal direction thus take place, by cooling and contraction, between the successive imaginary *couches*, taken from the exterior to the axis of the prism, which tend to cause the outer portions of the prisms to tear asunder at intervals in length dependent, like the diameter of the prisms themselves, upon the relation subsisting between the coefficient of contraction and of extensibility at rupture of the material.

The prism contracts not only in its length, but in its diameter; transverse fracture at its surface, when it occurs, is therefore due to the resultant of two orthogonal forces, the one parallel to the axis of the prism, as already referred to, and the other in a plane transverse to the axis. These two forces are proportionate, the first to the length of the prism from a preceding joint, or from its extremity, the second approximately to the semi-diameter of the hexagon; and the resultant of these two, at any point taken round the prism, is oblique to the axis, and tending toward it in direction. As fracture in a homogeneous solid always takes place transverse to the line of strain,

so the fracture producing a transverse joint takes place oblique to the sides of the prism; the obliquity becoming less as the fracture advances toward the axis of the prism, so that when complete it is cup-shaped, the convex surface of the fracture always pointing in the same direction as that in which the splitting of the prism itself is proceeding.

This solution, which is believed to be the first ever presented which, resting upon admitted laws, completely accounts for the production of the very remarkable cupped-shaped joints, is verified and illustrated by several diagrams, showing the mode of production of these joints, and the modifications of their curvature produced by varied conditions in the cooling.

It is further shown that the partial or complete detachment of certain fragments, frequently observed to be partially or wholly detached from the cusps of the concave side of these joints at and near the solid angles of the hexagon, is a consequence necessarily resulting from the mode of production of the joints themselves. The author then points out that in the case of very slender prisms other (and mechanical) conditions besides those of differential cooling enter into the production of the cross joints, which are at more considerable and irregular distances apart, and in planes of fracture often nearly transverse to the axis of the prism.

He also discusses the modifications produced in the prisms themselves, and in their cross joints, by heterogeneity in the mass of basalt itself—as, for example, by a more or less previously developed cleavage in the basalt in planes transverse to the axis of the prism, or by the presence of heterogeneous substances imbedded in the mass. To these latter, and to differences in conductivity, or in the cooling energy at different points of the cooling surface, are chiefly to be ascribed the divergencies from the normal hexagonal form of the prisms, as occasionally observed, the author remarking that where such divergencies occur they disappear, and the normal hexagonal form is returned to in such a manner as to require only the minimum expenditure of work.

The conditions producing greater or less interspaces between the prisms, which may vary from point to point of the same mass, are pointed out, as also those which cause the spaces between successive joints in adjacent prisms to coincide in successive planes, transverse to their axes, or the contrary.

The author then proceeds to discuss the various positions in space, and relatively to each other, which the axes of the prisms must assume, dependent on the general law, as already stated, that the axes of the prisms, however produced, are always normal to successive isothermal couches or planes at the splitting temperature, taken in succession within the mass.

If the mass be tabular, as already assumed, and cooling take place only from the top surface, the prisms will be straight and vertical, extending from top to bottom nearly of the tabular mass, and being separated from the bottom on which it rests by a more or less thick layer of irregular angular fragments, or of badly conducting material, tufa, scoriæ, &c., the convex surface of the joints all pointing downward. If the mass cool, both from the bottom and the top, the prisms, vertical and straight, will split upward and downward, and meet in an irregular intermediate stratum of angular fragments, the convex surfaces of the joints of the lower prisms pointing upward, and the respective lengths of the upper and lower ranges depending on their relative rates of cooling. If the tabular mass cool also from one or more of its sides, as by an abutting wall of rock, prisms will be produced with their axes perpendicular to that wall, and will be separated from the vertical ranges of prisms by an inclined stratum of angular fragments. Also if the basalt fill a crevasse producing a dyke, the prisms formed by cooling will be generally transverse to the plane of its walls, and meet somewhere toward the center in a stratum of more or less irregular fragments, due in all cases to the irregular contractions at the extremities of the prisms breaking up their mass there into wholly irregular forms. If the upper and cooling surface have a curved convex contour, the prisms shall be taper and convergent from the surface of the mass; and on the contrary, if the cooling surface have a concave contour, or rest upon a concave bottom, the prisms shall be divergent from the interior of the mass, the natural law of economy of work limiting the length or amount of taper in either case, limiting the length of the prisms, and a new range of larger diameter partially or wholly then commencing. The convergence or divergence are simple consequences of the general law, that the splitting takes place always normal to the isothermal *couches*, which are at the splitting temperature.

The author then proceeds to develop and illustrate by diagrams some of the varied and curious combinations which are observable in nature, and due to the more or less combined play of these conditions. He then proceeds to develop, as a consequence of the general law, the production of curved prisms, or those with apparently bent axes, which are observed in almost all basaltic countries. If the cooling mass of basalt be in one of its vertical sections of such a form that successive isothermal *couches*, taken in descending order, are not parallel to the original cooling surface, as they are in all cases of straight and parallel prisms, but divergent gradually from the cooling surface and from each other, then the lines of splitting of the prisms, always normal to these *couches*, must be curved

in one direction. This will be true whether the isothermal *couches* be plane surfaces divergent from a thinner to a thicker part of the mass, or whether they be curved surfaces arising from the mass reposing on a curved bottom, and diverging in like manner. This explanation of the production of curved prisms, without the necessary intervention of external mechanical forces, having bent into curves prisms originally formed straight, is, the author believes, here for the first time presented. He shows that great difficulties exist to the supposition that curved prisms are ever the result of the bending of prisms originally straight by extraneous mechanical effort. The author having thus shown that all the salient phenomena presented in nature by the forms, jointings, positions of the prisms, &c., of columnar basalt are accounted for as consequences of contraction in cooling, submits that this solution given by him must be the true one. He, however, proceeds to examine at some length the different views of those who have imagined that prismatic and jointed basalt has resulted from the squeezing together by some wholly imaginary external force of spheroidal masses, more or less resembling those known as "onion stones," or concretionary spheroids, such as those imagined by Mr. Gregory Watt. The author submits all points of the subject to a searching examination, and points out that, upon the only probable suppositions that can be made as to the pre-arrangement of such spheroids, no extraneous force of compression could produce prisms at all, but must squeeze the spheroids instead into rhombic dodecahedrons.

## SCIENTIFIC INTELLIGENCE.

### I. Chemistry and Physics.

1. *On Atmospheric Hydrogen Peroxide.*—Between the first of July and the first of December, 1874, Schöne examined one hundred and thirty specimens of rain, and twenty-nine specimens of snow, for hydrogen peroxide. These experiments were made in the vicinity of Moscow. Of the whole number of specimens of rain, only four failed to respond to the test, though out of the twenty-nine specimens of snow, twelve gave no reaction. Having established the fact, the author continued his investigations with reference to the following points: (1) Form of occurrence of hydrogen peroxide in the atmosphere; whether gaseous or dissolved in the fluid, or solid rain or hail; (2) Relation to other meteoric phenomena, to time of day and to season of the year; (3) Relation to the ozone of the atmosphere; (4) How produced in the air; (5) Part played by it geologically and botanically; (6) Action upon the animal economy when breathed; and (7) Hygienic

importance. For this purpose, all the rain, hail, snow, dew, and frost were collected and tested for hydrogen peroxide, the analysis being quantitative when possible. Further, at various times, especially in clear weather, artificial dew and frost were prepared and examined. Careful meteorological records were kept during the entire interval at the adjoining observatory. The ozone was determined by a Schonbein's ozonometer. The results show: that the quantity of hydrogen peroxide in rain varies from 0·04 to 1·00 milligram per liter; that the larger the drops, the greater the amount; that the first rain after dry weather is poorer in peroxide than that which falls later; that the peroxide is greatest when the wind is south and southwest, that in the rain brought by the equatorial current being greater than that which falls in the rain produced by the conflict of this with the polar current, or brought by the latter current itself; that the relative quantity of peroxide in rain increases from the summer solstice to the autumnal equinox, and then diminishes; that the quantity is not greater in rain which falls during a thunder-shower; and that during the four months, the absolute quantity of hydrogen peroxide contained in the 221 liters of rain which fell upon each square meter was only 62·9 milligrams. In snow there was only 0·05 mgr. peroxide to the liter, the amount diminishing toward the winter solstice. Natural dew and frost contain no peroxide, or at least, less than one twenty-five millionth of this substance. In artificial dew and frost, the amount of peroxide varied from 0·04 to 0·05 mgr. per liter, reaching on a bright moonlight night in summer 0·09 mgr. The amount increased with the altitude of the sun. The daily maximum was reached between 12 and 4 o'clock P. M., and the annual in the month of August. The amount is greater the lighter the temperature, the clearer the sky, the higher the absolute and the lower the relative humidity of the air. The author concludes that the peroxide is contained in the air both free and in solution, to the extent, as a maximum, of 0·000000268 c.c. in a liter. He also believes that sunlight plays an important part in its production. The experiments are still in progress.—*Ber. Berl. Chem. Ges.*, vii, 1693, Dec., 1874.

G. F. B.

2. *On the Absorption Spectra of Potassium and Sodium.*—Roscoe and Schuster have examined the absorption produced in the spectrum by the vapors of potassium and sodium. Fragments of the former metal, placed in tubes filled with hydrogen, were heated until the green vapors appeared. A continuous spectrum from a calcium light placed behind the tube, suffered absorption within it, and was examined by means of a Steinheil spectroscope of two prisms. A complicated absorption spectrum appeared, consisting of three groups of bands; the first, group $\alpha$, appeared first and was in the red; the second, $\beta$, was on the one side, and the third, $\gamma$, on the other of the D lines. These bands shaded off toward the red and resembled in general the bands of iodine. The position of the bands was approximately measured. Group

$\alpha$ consisted of nineteen bands, varying in wave-length from 6844 to 6275 ten-millionths of a meter; group $\beta$ of eight lines, from 6059 to 5901; group $\gamma$ of thirteen lines, from 5860 to 5667. The ordinary spectrum lines of the metal were not seen reversed owing to the too feeble intensity of the calcium light. Similar experiments with sodium led to similar results. The blue vapor gave an absorption spectrum showing in the blue a group of bands ($\gamma$) eleven in number, followed soon after by a group in the red and yellow ($\alpha$) consisting of twelve bands, and then by group ($\beta$) in the orange made up of seven bands. Sodium vapor in an iron tube heated to redness shows an absorption spectrum in which the red, the green and a part of the blue are removed. The D absorption lines widen considerably and a strong absorption band appears in the green. Hence only a part of the orange, the green and the ultra-blue are transmitted.—*Proc. Roy. Soc.*, xxii, 362; *J. Phys.*, iii, 344, Nov., 1874. G. F. B.

3. *Preparation of Glacial Formic Acid.*—In the ordinary preparation of strong formic acid, by passing hydrogen sulphide gas over lead formate, gently heated over a free fire, the product is always contaminated with sulphur products which communicate an unpleasant odor to the acid, and which cannot be removed. M. Berthelot finds that this may easily be avoided by conducting the decomposition at a low temperature. The well-dried lead formate is placed in a U tube which is immersed in an oil bath, the temperature of which must not surpass 130° C. Hydrogen sulphide is then slowly passed over it and the product is collected and purified by fractioning. Placed in a freezing mixture and solidified, it may be concentrated. The pure acid solidifies at a temperature of 8·6, a temperature considerably higher than that usually stated in the text-books.—*Bull. Soc. Ch.*, II, xxii, 440, Nov., 1874. G. F. B.

4. *On Phosphenylous Acid.*—Precisely as phosphorous chloride reacts with water to produce phosphorous acid, so phosphenylous chloride reacts to yield phosphenylous acid, according to the equation: $C_6H_5PCl_2+(H_2O)_2=C_6H_5PH_2O_2+(HCl)_2$. Michaelis and Ananoff have made use of this acid, discovered by them, for the purpose of getting some light upon the constitution of phosphorous acid itself. The phosphenylous acid is obtained in white crystalline plates, easily soluble in water and alcohol, and fusing at 70°. It is monobasic. The author describes the potassium, ammonium, calcium, barium, lead and iron salts. Between the two views held on the constitution of phosphorous acid, one that it is a trihydroxyl derivative of phosphorus, $P(OH)_3$, the other that it is derived from phosphoric acid by replacing hydroxyl by hydrogen and is $PO(OH)_2H$, the authors sought to decide from the reactions of phosphenylous acid. This may be considered either as $P(OH)_2C_6H_5$, or as $C_6H_5PO(OH)H$. Which of these formulas is correct, may be determined by the action of phosphoric chloride. In the first case the reaction is:

$$P(OH)_2C_6H_5+(PCl_5)_2=PCl_2C_6H_5+(POCl_3)_2+(HCl)_2,$$

the products being phosphenylous chloride and phosphoryl chloride. In the second case:

$$C_6H_5PO(OH)H+(PCl_5)_2=C_6H_5POCl_2+POCl_3+PCl_3+(HCl)$$

the products now being phosphenylous oxychloride, phosphoryl chloride, and phosphorous chloride. Experiment entirely confirmed the latter view. In the case now of phosphorous acid itself, the products given when it is acted on by phosphenyl tetrachloride must be according to one of two equations. In the first case: $P(OH)_3+(C_6H_5PCl_4)_3=PCl_3+(C_6H_5POCl_2)_3+(HCl)_3$. In the second case, the reaction is:

$$OPH(OH)_2+(C_6H_5PCl_4)_3=POCl_3+(POCl_2C_6H_5)_2+C_6H_5PCl_2+(HCl)_3.$$

The phosphorous acid was prepared by acting on the chloride with water, and was treated with the tetrachloride in a flask. Phosphoryl chloride, but no phosphorous chloride, was formed. The fraction of the distillate boiling above 220° gave, when treated with water, phosphenylous and phosphenylic acids, thus proving the presence of the corresponding chlorides, $POCl_2C_6H_5$ and $PCl_2C_6H_5$. The authors believe, therefore, that the formula $OPH(OH)_2$ represents the true constitution of phosphorous acid. —*Ber. Berl. Chem. Ges.*, vii, 1688, Dec., 1874. G. F. B.

5. *On the Production of Sarcolactic Acid by Fermentation.*—Maly some time ago showed that, under the influence of the mucous coat of the stomach, many of the carbohydrates, as cane-sugar, grape-sugar, milk-sugar, dextrin, etc., were converted into lactic acid. The ferment in this case is a product of the dead tissue, since the living mucous membrane has no power to effect this conversion. Since that time, the author has observed that often, but not always, there is simultaneously formed some sarcolactic acid, proved to be such by the composition of the zinc salt and its much greater solubility. The precise conditions under which this formation takes place have not been determined; though in one case sarcolactic acid was the sole product. This acid has been alike produced from grape and from milk-sugar; the separation of the two zinc salts being effected by fractional crystallization. Maly also mentions the discovery of sarcolactic acid in the fluid of an ovarian cyst, far from muscular tissue.—*Ber. Berl. Chem. Ges.*, vii, 1567, Dec., 1874. G. F. B.

6. *On the Antiseptic Action of Salicylic Acid.*—Knop, at Kolbe's suggestion, has made some experiments to ascertain the action of salicylic acid upon vegetation. The results prove that this acid has a marked action upon the vegetative activity of cells, whether these be the chlorophyll cells of the higher or the non-chlorophyll cells of the lower orders of plants, provided only the acid remain free in the liquid. Two vigorous maize plants, 4 or 5 decimeters high, grown in his well-known solution and well rooted, were immersed in 500 c.c. of this solution, to which had been added 100 c.c. of a solution of salicylic acid containing 0.4 per cent of the acid. A third, fourth and fifth plant was simi-

larly treated, using tartaric, citric, and lactic acids respectively in place of salicylic. In the salicylic solution, the roots were killed. The new roots put out during the duration of the experiment became dark upon their ends, and under the microscope their cells were seen to be markedly affected, the protoplasm separating from the cell-walls. A second crop of roots fared similarly; but the third was more successful, and the plant continued to live in the solution for a long time. No mould, however, formed on the surface of the liquid even after three weeks. The other acid solutions killed the maize plants in three weeks, but the surfaces were covered with a thick layer of mould. Neither maize nor buckwheat grains germinate after soaking in water to which an equal volume of a saturated solution of salicylic acid has been added, not even by planting in earth. Fifteen grains of corn were soaked in water containing $\frac{1}{10000}$ of salicylic acid, and then placed in a germinating fluid consisting of 50 c.c. gypsum solution, 50 c.c. solution salicylic acid of 0·1 per cent, in a liter of water; 14 failed to germinate. The same fact appeared with buckwheat, wheat, rye, and oats. A similar depression of vegetative activity was observed in the case of mould; the difficulty of germinating seeds in solutions in June and July, owing to the rapid production of mould, being entirely obviated by the use of a highly dilute solution of salicylic acid.—*J. pr. Ch.*, II, x, 351, Nov., 1874.

G. F. B.

7. *Outlines of Proximate Organic Analysis;* by ALBERT B. PRESCOTT, Professor of Organic and Applied Chemistry in the University of Michigan. 192 pp. 12mo. New York, 1875 (Van Nostrand).—This work is a useful and much needed laboratory manual, for the identification, separation, and qualitative determination of the more commonly occurring organic compounds. It is well arranged for the use of the student in the laboratory, and will be found valuable also to the teacher. It is to be followed by a manual of the "Chemical Examination of Alcoholic Liquors," by the same author.

8. *Passage of Gases through Liquid Films.*—Dr. F. EXNER has determined quantitatively the penetration of various gases through the film of a soap bubble, an effect shown qualitatively by Draper and Marianini. Calling C the co-efficient of absorption of the gas for the liquid of which the film consists, and $\delta$ the density of the gas, he has deduced the law that the velocities of diffusion of gases are proportional to C divided by $\sqrt{\delta}$. For the diffusion velocities of the gases examined, putting that of air = 1, the following numbers were found by observation: N = 0·86, O = 1·95. Illuminating gas = 2·27, H = 3·77, $CO^2$ = 47·1, $H_2S$ = 651, $NH_3$ = 46,000. Within these extraordinarily wide limits, between 0·86 and 46,000, the observations are in perfect accord with the formula $\frac{C}{\sqrt{\delta}}$. Experiments were also made for the purpose of ascertaining the absolute velocity of diffusion. These gave for the diffusion of H in air through a soap film, that in one minute 1·88

cubic centimeters H and ·50 cub. centim. of air simultaneously pass through one square centim. of the film.—*Roy. Acad. Sciences, Vienna*, Nov. 5th, 1874; *Phil. Mag.*, xlviii, 547. E. C. P.

9. *Late improvements in Magneto-Electric Machines.*—M. L. T. Gramme describes the improvements effected in the machine which bears his name, by which its power is greatly increased. In 1872 one machine was made for producing the light, two for plating, and several small machines. The latter could redden 10 cms. of platinum wire ·3 mms. in diameter. Those now made redden 60 cms. of the same wire, though there is no increase in the cost or weight. This large increase is principally due to the employment of the new magnets in sheets of Jamin. In 1872 and 1873 twelve large machines for plating were constructed weighing 750 kgs. and containing 175 kgs. of copper apiece. Their height was 130 cms., their length 80 cms., they deposited 600 grams of silver per hour and required for this work a force of 75 kilogrammeters. The new plating machine has but one central ring instead of two, weighs 177 kgs. and contains 47 kgs. of copper. Its dimensions are 55 cms. on a side and 60 cms. high. Like the other, it deposits 600 grs. per hour, but requires only 50 kgmtrs. to run it. It therefore occupies but one-half the space of the old form, the weight is reduced three-quarters and the motive force one-third. These improvements are effected by suppressing the exciting bobbin, putting the electro-magnet directly into the circuit, by a better arrangement of the copper, and by slightly increasing the speed. The coils, instead of being formed of wire, are now constructed of a band of thin copper, of width equal to one-half the length of the bars of the magnet, so that four large ribbons are used for each machine.

The plan of putting the electro-magnet into the main circuit gives rise sometimes to a curious change in polarity. When the machines are in motion, and the circuit closed through metallic baths, the direction of the current remains the same indefinitely. But if suddenly stopped, the current induced by the electro-magnet reverses the polarity of the latter, so that if the machine is again started the current passes in the opposite direction and removes the silver it has just deposited. To avoid this trouble, he inserts in the circuit an electro-magnet, which ordinarily hold up an armature, and keeps the circuit closed, but as soon as the speed slackens below a certain point, the armature drops and breaks the circuit, thus preventing the induced current. By applying these improvements to the old form of machine, its capacity was at once raised from 600 to 2,100 grams per hour.

The first machine for generating the light weighed 1,000 kgs., the copper of the magnets weighing 250 kgs., that of the ring 75 kgs. The space occupied was 80 cms. on a side and 125 cms. high. This was used a long time in the tower of Westminster, and for two years has not given much trouble, though it heated a little and gave sparks around the commutator. The new form weighs 183 kgs. and contains only 47 kgs. of copper. Its length

and breadth are 55 cms., and its height 60 cms. The capacity is however much less, being only 200 Carcel burners, instead of 1,000. A greater light may nevertheless be obtained by an increased speed, as is shown by the following results of ten series of experiments: 650 turns gave a light of 77 burners; 850 gave 125; 880, 150; and 900, 200 without heating or sparks. 935 gave 250 with slight heating, and 1,025 gave 290, but produced heating and sparks. Comparing with the machine of the company of the Alliance, in use at the lighthouse of La Hève, we find that this also gave a light of 200 burners, but weighs 2,000 kgs. and occupies a space of 170×135×150 cms. Its weight is therefore twelve times as great, the surface covered seventeen times as great, and the volume eighteen times as great.

These machines having neither cranks, connecting shafts or dead-points, are well adapted to the transformation of electricity into work. One of the small machines gave the results shown in the accompanying table, when run with Bunsen cells of 0·20. The first column gives the number of cells, the second the number

| Cell. | Turns. | Power. | Cell. | Turns. | Power. |
|---|---|---|---|---|---|
| 2 | 760 | ·32 | 7 | 1100 | 4·14 |
| 3 | 810 | 1·02 | 8 | 1100 | 5·00 |
| 4 | 1000 | 1·02 | 8 | 900 | 4·81 |
| 4 | 900 | 1·80 | 9 | 1500 | 5·11 |
| 5 | 1100 | 2·50 | 10 | 1700 | 5·52 |
| 6 | 1000 | 3·36 | 10 | 1300 | 6·16 |

of turns, and the third the work done in kilogrammeters. This suggests a convenient method of transmitting power, placing one machine near the source, and transmitting the current to any distance by a wire or cable. A conclusive experiment was made as follows: a machine was driven by a steam engine, by a power of 75 kgmtrs., determined by a friction brake. The current moved a second machine with a second brake, which gave 39 kgmtrs., or more than half. But as the power was first changed into electricity and then the electricity into power, the coefficient of efficiency of each machine must have been over 70 per cent.

A curious form of machine is made by winding with two wires, one coarse, the other fine. The current from two Bunsen cells is then passed through the first, running the machine, and producing a current of high tension in the fine coil. A telegraph may thus be run by two Bunsen cells.—*Compt. Rend.*, lxxix, 1178. Articles fully illustrated on the same subject may also be found in *Engineering*, Nov. 27th, 1874, and in the *Annales Industrielles.* E. C. P.

10. *Expansion of Phosphorus.*—Mms. Pisati and DeFranchis have measured the expansion of both solid and liquid phosphorus at temperatures from 0° to 270° C. They employed a cylindrical dilatometer with a graduated neck. This was immersed in a bath of oil kept stirred continuously, and the greatest errors were estimated at a tenth of a degree. The readings were all reduced to degrees of the air-thermometer by a direct comparison. From a

large number of experiments they deduced the following results. The specific volume of solid phosphorus is given by the equation:

$$w_t = w_0 + 2000 \times 10^{-7} t + 1150 \times 10^{-10} t^2$$

and of liquid phosphorus by:

$$w_t = w_{50} + 2969 \times 10^{-7} (t - 50) + 2115 \times 10^{-10} (-50)^2$$

The mean co-efficient of dilatation per degree for solid phosphorus from 0° to $v°$ is given by the formula:

$$R = 3674 \times 10^{-7} + 211 \times 10^{-9} t,$$

and for liquid phosphorus:

$$R = 5167 \times 10^{-7} + 370 \times 10^{-9} (t - 50).$$

—*Gazz. Chim. Ital.*, iv, 1874. E. C. P.

11. *Velocity of Light.*—M. Cornu gives the results of some measurements he has made on the velocity of light under the direction of the Council of the Observatory, at the suggestion of LeVerrier and Fizeau. The method employed was that of the toothed-wheel, first employed by Fizeau in 1849. The result then obtained was 298,500 meters from measurements between the Polytechnic School and Mt. Valérian. The stations now selected were the Observatory and the tower of Montlhery, distant about 23 kilometers, a distance accurately determined, and famous for its use in the determination of the meter, and more recently for the velocity of sound. The telescope at the Observatory had a focal length of 885 cms. and an aperture of 37 cms., the other a focal length of 200 cms. and an aperture of 15 cms. A simple reflector was placed at its focus, and the whole was enclosed in a large iron tube and built into the wall. The toothed wheel could be turned with any velocity up to 1600 turns per second, and by a chronograph and electric register the time measured to thousandths of a second. The method of measurement is well known, and the precise time of disappearance was marked and the velocity measured electrically. This was necessary, since it was impossible to preserve a perfectly uniform motion. 504 observations were thus taken, and the results are given in the following table. The column headed $n$ gives the number of teeth that passed during the passage of the light; the column headed $m$ gives the number of times the observation was made, and the column V gives the corresponding velocity. The mean of the whole, giving

| $n$ | $m$ | V | $n$ | $m$ | V |
|---|---|---|---|---|---|
| 4 | 15 | 300,130 | 13 | 4 | 300,340 |
| 5 | 33 | 300,530 | 14 | 9 | 300,350 |
| 6 | 20 | 300,750 | 15 | 65 | 300,290 |
| 7 | 10 | 300,820 | 16 | 4 | 300,620 |
| 8 | 7 | 299,940 | 17 | 22 | 300,000 |
| 9 | 94 | 300,550 | 18 | 35 | 300,150 |
| 10 | 69 | 300,640 | 19 | 6 | 299,550 |
| 11 | 72 | 300,350 | 20 | — | ——— |
| 12 | 3 | 300,500 | 21 | 36 | 300,060 |

proper weights to each, is 300,330 in air, or 300,400 meters in vacuo, with a probable error of only one-tenth of one per cent.

The methods of measuring the parallax of the sun may be divided into three classes. 1st. The physical methods dependent on optical phenomena. They include the eclipses of the satellites of Jupiter and aberration of the fixed stars, together with the value of the velocity of light. Employing the results here obtained give 8″·88, 8″·88 and 8″·80, or a mean 8″·85 as the solar parallax. 2d. The analytical methods of astronomical observations with theoretical laws based on the theory of gravitation. They give the value 8″·86. 3d. The purely geometrical methods by the parallax of the planets near the earth. The opposition of Mars in 1862 gave 8″·84. But the greatest accuracy is attained by the observations of the transit of Venus.—*Comptes Rendus*, lxxix, 1361. E. C. P.

12. *On a new way of illustrating the Vibrations of the Air in Organ Pipes;* by Prof. JOSEPH LOVERING, of Cambridge, Mass. (From the Proceedings of the American Association for the Advancement of Science, vol. xxiii.)—I shall begin with a brief description of the methods adopted by W. B. Rogers and Kœnig for making visible the vibrations of the invisible air in organ pipes. By the first method two gas burners were fed from a common reservoir; a glass tube was placed over one burner and the length of the flame altered until it was brought into unison with the fundamental note of the tube, and an energetic vibration of the flame and the column of air began. The flame on the other burner also vibrated from sympathy. The individual vibrations of this naked flame were unraveled by making the burner revolve in a small circle of about one inch in diameter. A cylindrical sheet of light resulted from the motion, which was channelled by dark spaces as soon as the sound was heard. The method has the advantage of giving an object which can be seen in all directions, with the disadvantage, however, on account of the small circle in which the flame travels, of crowding upon each other the alternate dark and bright spaces of the fluted surface.

The description just given has reference to the apparatus constructed by Kœnig under the name of the *Appareil à flammes chantantes de M. le Comte Schaffgotsch.* But I have not been able to find in Schaffgotsch's account of his apparatus and experiments any allusion to this method of exhibiting to the eye the individual vibrations by the revolution of the flame itself. Probably, it was an appendage to Schaffgotsch's apparatus suggested to Kœnig by the experiment of Prof. W. B. Rogers.*

In this experiment only a single flame was employed; a tube being placed over it large enough to allow the interior flame to revolve in a small orbit.

The second method for accomplishing the same object is a device by Kœnig, and is known under the name of the *Manometric Flames.*† An opening is made in the side of an organ pipe at the place where the greatest changes of density occur when the pipe is sounding: to this hole he applied a small box, the end which is placed upon the hole being covered with a delicate membrane.

* Amer. Journ. Science, xxvi, 1858. † Ann. Chem. und Phys., cxxii.

Gas is introduced into this box by one tube and then conducted from the box to the burner by another tube. The vibrating air in the pipe plays upon the membrane, and communicates vibration to the flame. The individual vibrations of the flame are revealed to the eye, by reflecting it in a revolving mirror after the manner of Wheatstone. Four mirrors placed upon the four vertical sides of a revolving cube produce the same effect with a smaller velocity. This method has the disadvantage of substituting for the flame itself a faint and virtual image, not easily seen in daylight or in all directions. It has the advantage of admitting of a large orbit of revolution and thus separating widely the individual vibrations of even high notes.

I have endeavored to combine the advantages of both methods without incurring their disadvantages. Imagine eight arms of gas pipe, each one foot in length, arranged as the spokes of a horizontal wheel upon a hollow hub, which is lengthened out below to the extent of six inches. This hub is closed at the upper end by steel and is balanced upon a steel point at the top of a hollow upright through which the gas is delivered. Two holes are made in the sides near the top, through which the gas flows out into the hollow hub and the attached arms. The upright comes up through the bottom of a vessel, into which water is poured in sufficient quantity to immerse the bottom of the hub and prevent leakage of the gas below. In this way great freedom of motion is secured on the steel point, with a perfectly tight joint. The arms are rotated in a large circle by clock-work, and their weight suffices to make them serve as a fly-wheel and acquire a uniform motion. The arms are closed at the ends, and the gas issues in eight vertical streams from as many holes in the tops of the arms. When these streams are lighted, the rotation produces a large cylindrical sheet of light. The greater the number of arms the smaller is the velocity required to produce persistency of impression in the eye, with the additional benefit of having a well-balanced instrument. Vibration of the flames is produced by attachments to the organ pipes similar to those used by Kœnig. When the full pressure of the gas is on, the cylindrical sheet of light is three or four inches in height, and, when the organ pipe speaks, it is broken up as neatly as when the virtual image is used in Kœnig's apparatus. The effect can be seen readily in full daylight and from every part of a large room. The best effect is with organ pipes at least three feet in length and open at both ends. Of course, the serration is finer when shorter pipes are used. The experiment is very beautiful, even with short pipes, if the flame is brought down to the size of a pea. In this case the illuminated circle, as soon as the sound begins, is broken up into bright beads loosely strung upon a dark cord. On one side of each flame a screen is placed, which moves on a hinge and can be set at any angle with the plane of rotation. These screens serve the double purpose of checking the velocity, if the energy of the clock movement is too great, and of preventing the flame from flaring if the motion is too rapid. For pur-

poses of research, Kœnig's apparatus may be all that is desired. But for illustration in class rooms, and especially to large numbers, the new arrangement just described will be found to possess great advantages.

## II. Geology and Natural History.

1. *New Order of Eocene Mammals.*—At the last meeting of the Connecticut Academy, Feb. 17th, Professor O. C. Marsh made a communication on a new order of Eocene Mammals, for which he proposed the name *Tillodontia.* These animals are among the most remarkable yet discovered in American strata, and seem to combine characters of several distinct groups, viz: Carnivores, Ungulates, and Rodents. In *Tillotherium* Marsh, the type of the order, the skull has the same general form as in the Bears, but in its structure resembles that of Ungulates. The molar teeth are of the ungulate type, the canines are small, and in each jaw there is a pair of large scalpriform incisors faced with enamel, and growing from persistent pulps, as in Rodents. The adult dentition is as follows:—Incisors $\frac{2}{2}$; canines $\frac{1}{1}$; premolars $\frac{3}{2}$; molars $\frac{3}{3}$. The articulation of the lower jaw with the skull corresponds to that in Ungulates. The posterior nares open behind the last upper molars. The brain was small, and somewhat convoluted. The skeleton most resembles that of Carnivores, especially the *Ursidæ*, but the scaphoid and lunar bones are not united, and there is a third trochanter on the femur. The radius and ulna, and the tibia and fibula are distinct. The feet are plantigrade, and each had five digits, all terminated with long, compressed and pointed, ungual phalanges, somewhat similar to those in the Bears. The other genera of this order are less known, but all apparently had the same general characters. There are two distinct families, *Tillotheridæ*,* in which the large incisors grew from persistent pulps, while the molars have roots; and the *Stylinodontidæ*, in which all the teeth are rootless. Some of the animals of this group were as large as a Tapir. With *Hyrax* or the *Toxodontia* the present order appears to have no near affinities.

2. *On the alleged parallelism of Coal beds;* by J. J. Stevenson. (Proc. Amer. Phil. Soc., xiv, 283.)—Mr. Stevenson in this paper gives examples, from this country and England, of the subdivision of coal beds, and of variations in the thickness of the intervening rock strata. The interval between the Upper Freeport and Kittaning coal beds along Yellow Creek in Ohio varies from 80 to 160 feet in five miles. The same interval on Wells Creek varies in one mile from 8 feet to 28, and from this it enlarges beyond [distance not stated] to 110 feet. In six sections given by Prof. Rogers in his Pennsylvania Report the intervals are 184, 143, 142, 117, 109, 103. The total interval between the Pittsburgh coal bed and the Upper Freeport varies in Ohio from

* This family may possibly prove to be identical with *Anchippodontidæ.*

420 feet at the west to 505 at Steubenville; in Pennsylvania it is 200 feet at Ligonier, 220 at Elk Lick, and 450 to nearly 600 feet on the Monongahela River; in West Virginia, along the Monongahela and Tygart's Valley River, it varies not much from 420 feet.

Mr. Stevenson, after stating many other facts, observes, in conclusion, that the variation in thickness arises mainly from the fact that the beds were deposited in a great trough having the Cincinnati uplift on one side and the Alleghany region on the other; that the diminution in thickness is quite regular east and west from the middle of the trough; that the subsidence as a whole was regular, approaching uniformity, but that there were "bulgings or other irregularities such as could not fail to accompany any operations so extensive." He further concludes that "all the coals of the Upper Coal group are offshoots from one continuous marsh, which existed from the beginning of the era to its close, and which in its full extent is now known as the Pittsburg coal seam."

3. *Diatoms of the Carboniferous.*—Count F. CASTRACANE of Rome has found, in an examination of the ashes of mineral coal from Liverpool, a large number of species of Diatoms. The most of them are freshwater; but with these occur a number of marine kinds.—*Am. Mag. Nat. Hist. for February, from the Actes de l' Acad. Pontif.*, Feb., 1874.

4. *A new Mastodon.*—Professor COPE has announced his obtaining *Elephas primigenius* var. *Columbi* from Quarternary beds at the base of the Zandia Mountains, and the *Mastodon Ohioticus* from corresponding beds near Taos, and from the valley of the South Platte in Northwestern Colorado. The Pliocene of Santa Fé affords the remains of a Mastodon, referred by Leidy to his *M. obscurus*, of which Cope makes a new species, *M. productus.*

5. *The Geology of New Hampshire. A Report comprising the results of Explorations ordered by the Legislature.* C. H. HITCHCOCK, State Geologist; J. H. HUNTINGTON, Principal Assistant. *Part I, Physical Geography.* 668 pp. roy. 8vo, with many illustrations. Concord, 1874.—This First Part of the Report on the Geology of New Hampshire commences with a history of the Geological Surveys in New Hampshire by Prof. Hitchcock. The chapters on this subject are followed by a history of explorations among the White Mountains by W. Upham; a chapter on the climatology of New Hampshire by J. H. Huntington; another excellent one on the use of the magnetic needle in surveying by E. T. Quimby, illustrated by maps; others on the topography of the State by C. H. Hitchcock, including a long catalogue of altitudes from railroad and other surveys; another on the river-systems by W. Upham; on the distribution of Insects in N. Hampshire, with a map, by S. H. Scudder (noticed on page 232); on the distribution of Plants by W. F. Flint; on the Natural History of the Diatomaceæ by A. Mead Edwards, with a plate; and chapters on the Scenery of the State by C. H. Hitchcock and J. H. Huntington. The illustrations are numerous and a number of them are photographic.

The survey has brought much to light that is new respecting the geology of New Hampshire. The occurrence in metamorphic New England of Upper Silurian fossils within a few miles of the White Mountains, which it has made known, is a fact of the highest geological importance; and that of the labradorite and chrysolite rocks in the White Mountain region is another. These discoveries are enough of themselves to prove the survey a success as far as geological science is concerned; for they are destined to give great aid toward unravelling the knotty points in New England geology.

Professor Hitchcock has reserved the details respecting these and the other geological results for another volume, and has given in the one issued—on the Physical Geography of the State—only his general conclusion with regard to the *ages* of the crystalline rocks, the facts being brought out in a chapter on "the physical history of New Hampshire." This subject, moreover, is illustrated by a series of six colored maps representing the supposed geography—or areas of dry land and water—of the region of New Hampshire and Eastern Vermont during these several ages, four of which are made *pre-Silurian*, one *Cambrian* or *Primordial*, and one *Helderberg*. We only remark that the author does not seem to have sufficiently appreciated the fact that in a region which is metamorphic throughout, the immense amount of denudation that has taken place in past time throws great doubt over all attempts to mark out over it outlines of the *dry land* of successive pre-Silurian ages by the present superficial distribution and positions of the different kinds of rocks.

Some other opinions in Professor Hitchcock's part of the volume appear to us to need revision.

After speaking of the "extremely abundant Laurentian vegetation" (p. 508), he observes, with regard to the origin of beds of iron pyrites and copper pyrites in his "Huronian rocks," that "For the formation of sulphurets we require originally a sulphate ocean, just as in the case of gold," and then speaks of the deoxidizing agency of vegetation, reducing the sulphates to sulphurets; but he does not explain how "an extremely abundant vegetation" could have existed in "a sulphate ocean."

Mr. Hitchcock recognizes the existence of a long Azoic era, as well as Eozoic era, in pre-Silurian time, and then objects to the term *Archæan* for the pre-Silurian, on the ground that the terms Azoic and Eozoic are sufficient alone. In this we should agree with him *if* the rocks of the Eozoic part of the pre-Silurian time could in all cases be distinguished from those of the Azoic.

The existence of great beds of iron ore in pre-Silurian terranes is regarded as evidence (in this following Prof. T. Sterry Hunt) of the existence during the era of abundant vegetation—on the ground that, in making marsh-beds of iron ore, the oxide of iron, when carried in by the waters, is in the state of iron-salts of organic acids. But the era was a very long one: Helmholtz made the time which elapsed during the cooling from 2,000° C. to 200° C.

350,000,000 of years; and many more millions should be added for the continuation of the cooling down to 100° C.; all of which necessarily antedated the first appearance of the simplest forms of life; and more still to reduce the temperature to 38° C. (100° F.), which limit was probably reached before the close of the Archæan. And in that long era, even to its close, the atmosphere certainly contained a greatly larger proportion of carbonic acid than now, if not also other acids; and also, for this reason, it had much greater density. Hence carbonic acid, which does now some of the work of iron-transportation, may have done far more then. It is surely very unsafe to conclude from the existence of those iron ore beds that the vegetation was extremely abundant, or that any then existed.

Neither does the phosphate of lime (apatite), which is so generally disseminated through the iron ores, afford good evidence of life. The amount of this mineral in Archæan rocks exceeds that in all the later rocks of the globe, and would certainly indicate the existence of an extraordinary amount of life over the Archæan marshes and lands if of any at all. Some of the earliest shells of the Silurian (*Lingulæ* and a few related kinds) consist largely of phosphate of lime, as shown by Hunt, and this appears to prove, as this author has observed, that the waters of the ocean then held in solution more phosphates than they now do. And the grains or crystals of phosphate of lime in the iron ore may be proof only of the same fact with regard to the ocean's waters. The chemistry of the globe during any part, even the last, of the hundreds of millions of years before the opening Silurian is too doubtful for positive speculation as to what chemistry did not do and life did.

On the question of the animal nature of the *Eozoon* Prof. Hitchcock writes judiciously, excepting in a single remark. He observes that "those who disbelieve the organic theory are mostly better skilled in mineralogy than biology." But Messrs. King and Rowney, the chief contestants, are not mineralogists, but zoologists, and Mr. Carter of England, another strong opponent of the "organic theory," is also a zoologist, and one particularly versed in the lower orders of animal life. There are probably mineralogists that doubt, as there certainly are zoologists, but we can recall no articles by any such on the subject, excepting one or two which aim to show that the limestones containing *Eozoon* are sometimes of igneous origin, an observation which, whether sustained or not, cannot be attributed to mineralogical prejudices.

Notwithstanding some exceptions to the volume, we regard it as a repository of much valuable information on the physical geography and productions of the State.

6. *First Annual Report of the Geological and Agricultural Survey of Texas;* by S. B. Buckley, State Geologist. 142 pp. 8vo. Houston, Texas, 1874.—This Report is occupied mainly with observations of economical interest relating to soil, rocks, ores, trees. There are brief notices of the Tertiary, Cretaceous and older

rocks. But these show much ignorance of the subject. In a paragraph headed in capitals DEVONIAN, we find the author saying that "in 1860, when engaged with Dr. Shumard in the survey of San Saba County, some of the limestones and shales in the eastern part of that county were referred by him to the Devonian. The Trenton limestone was the formation recognized: its chief fossils found were of the following genera: *Belerophon*, *Maclurea*, *Orthis*, *Murchisonia*, *Pleurotomaria*, and some other genera of that period." A "State geologist" who refers the Trenton limestone to the Devonian is evidently not a geologist, whatever his State appointment. Such a mistake Dr. Shumard could not have made.

Another specimen of the Report may do its author better justice. In the chapter, a little over a page long, on the Jurassic of the State, three lines are used in stating that half a mile west and northwest of Phantom Hill, Callahan Co., there are "what may be fossils of the Jurassic period;" and three more in saying, "Intending to make a more careful study of them, I placed them in a box and shipped them to Austin, since which I have not seen them." The rest of the page on the Jurassic is occupied with an account of the scenery, buffaloes, etc., of Callahan County, in the course of which he says: "Old buffaloes, especially the old bulls, delight to roll and wallow in the soft dirt. I have seen them roll and kick up their heels, over and over, and then get up and shake themselves apparently with great satisfaction. It will not be many years before Northwest Texas will be resorted to by crowds of Northern invalids for the purpose of breathing its pure air, to behold its charming landscapes, and hunt and fish; hunt the buffalo, the antelope, the deer, wild turkeys, etc., and catch thousands of fish. Such pastimes will kindle the spark of life anew, and give new life to the body." This much for the Jurassic.

The Report contains charges against the late Dr. Shumard and his assistant, Mr. A. R. Roessler, which should have been stricken out by the Governor of Texas, to whom the Report is addressed, before the manuscript was sent to the printers. Dr. Shumard was an excellent geologist, and we believe an honorable man.

7. *Second Geological Survey of Pennsylvania. Report of Progress for* 1874; by PETER LESLEY, Director of the Survey.—The appointments for this new survey were not made until the month of June had far advanced, and consequently the parties were not in the field until July and August. The assistants appointed are: Mr. A. S. McCreath, chemical assistant; Prof. F. Prime, Jr., assistant in charge of the Lehigh district: Prof. P. Frazer, Jr., in charge of the York and Adams district; J. H. Dewees, in charge of the Juniata district; F. Platt, in charge of the Clearfield and Jefferson coal district; J. F. Carll, in charge of the Venango oil district; Dr. F. A. Genth, chemist and mineralogist; H. E. Wrigley, on the petroleum region of Western Pennsylvania; E. B. Harden, draughtsman. Two more assistants are to be appointed, one for Greene and Washington Counties, and

the other for the northern tier of counties, Tioga, Branford, Susquehanna and Wayne. Besides these there are a number of volunteers.

Although the parties were late in the field, valuable results have been obtained, which will soon be published in the Report for the year. Dr. Genth's Mineralogical Report is nearly printed; it will extend to about 150 pages. The geological reports of Professor Frazer, Professor Prime, Mr. Platt and Mr. Dewees, illustrated by several maps and sections, are finished and are either in the printer's hand or will soon be. Besides these, the volume for 1874 will include a special report on petroleum by Mr. H. E. Wrigley, which will contain a large map of the oil regions of West Pennsylvania and West Virginia, a small map of the oil regions of the Middle States and Canada, sections and other illustrations. Mr. Lesley's extensive knowledge of geology, theoretical and practical, and of the range of subjects that will come under investigation in the survey, together with his thoroughness and energy, ensures for the State of Pennsylvania, and for the science of the land, results of the highest value.

8. *Geographical Explorations and Surveys west of the 100th Meridian;* First Lieut. G. M. WHEELER, Corps of Engineers, U. S. A., in charge.

(1.) *Preliminary Report upon Invertebrate Fossils collected in* 1871–1873, with descriptions of new species; by C. A. White, M.D.—The species included are from the Primordial of the Cañon of the Colorado, Mohave Co., Arizona, the vicinity of Antelope Spring, House Range, Utah, and Pioche in Nevada; from the Quebec group of Utah and Nevada; the Trenton beds in Nevada, New Mexico and Arizona; the Subcarboniferous of Arizona, Nevada and Utah; the Carboniferous of Arizona, New Mexico and Nevada; the Jurassic period of Utah and Arizona; the Cretaceous of New Mexico, Arizona and Utah.

(2.) *Report upon Ornithological Specimens collected in* 1871–1873. 148 pp. 8vo. 1874.—Contains a Report on the birds collected in 1872, by Dr. H. C. Yarrow and H. W. Henshaw; on those of 1873, by H. W. Henshaw; annotated list of the birds of Utah, by H. W. Henshaw. The papers are full of valuable notes.

9. *Notes on the Natural History of portions of Montana and Dakota*, being the substance of a Report to the Secretary of War, on the collections made by the North Pacific Railroad Expedition of 1873, Gen. D. S. Stanley, Commander; by J. A. Allen, Naturalist of the Expedition. 62 pp. 8vo. 1874. (From the Proc. Bost. Soc. Nat. Hist., vol. xvii, June, 1874.)—Consists of notes on the Mammals, Birds, Reptiles, Amphibians, Plants and Butterflies collected by the Stanley Expedition.

10. *Geological and Geographical Survey of the Territories;* Dr. F. V. HAYDEN, Geologist in charge. Department of the Interior.

(1.) *Seventh Annual Report*, for 1873. 718 pp. 8vo. Washington, 1874.—This report is noticed from an incomplete copy, extending to page 533, in the December number of this Journal. A complete bound copy reached us on the 11th of February. The closing

part includes Reports on Insects by W. L. Carpenter, C. R. Osten Sacken, H. A. Hagen; on Crustacea by S. I. Smith and A. S. Packard; on the methods of Topographical Survey by James T. Gardner; Topographical Report on the Middle Park Division by S. B. Ladd, and on the Gold Hill Mining Region, by A. R. Marvine. A further notice is reserved to another number.

(2.) *Bulletin, Second Series*, No. 1. 48 pp. 8vo. 1875.—Contains memoirs on the Fishes of the Tertiary shale of the South Park, by E. D. Cope; On the Cranial and Dental Characters of Mephitinæ, with description of *M. frontata*, a new species from the bone-caves of Pennsylvania; Ancient ruins in Southwestern Colorado, by W. H. Jackson, with four plates; on fossils from near the eastern base of the Rocky Mountains, west of Greeley and Evans, Colorado, and others from about 200 miles farther east, with descriptions of a few new species, by F. B. Meek.

(3.) *Contributions to the Fossil Flora of the Western Territories. Part* 1, *The Cretaceous Flora;* by Leo Lesquereux. 136 pp. 8vo, with 30 lithographic plates. Vol. vi. of the Reports.—Mr. Lesquereux has here brought out the results of his long and careful study of the Cretaceous flora of the Rocky Mountain region. The plants described are from the Dakota group, the lowest of the Cretaceous beds in that region. The facts show that the leaves lie near where they were dropped. The localities are between the parallels of 39° and 47°; and the leaves indicate a general uniformity of climate over these parallels, with perhaps a slightly warmer temperature in Kansas, where alone occur the genera *Credneria*, *Pterospermites* and *Dombeyopsis;* where the species of *Liriodendron*, and of some other genera have large leaves, while those of the Nebraska species are small. The climate indicated, according to Lesquereux, is like that now existing between the parallels of 30° and 45°, as is inferred from the occurrence of the genera *Salix*, *Fagus*, *Platanus*, *Sassafras*, *Aralia*, *Magnolia*, *Liriodendron*, *Menispermum*, *Rhus* and others.

He observes also that Heer finds evidence of the same climate in Greenland during the Upper Cretaceous, 28 species of the genera *Populus*, *Myrica*, *Ficus*, *Sassafras*, *Proteoides*, *Credneria*, *Andromeda*, *Diospyros*, *Panax*, *Magnolia*, *Rhus*, and others having been identified by him from beds in latitude 70°; while from the Lower Cretaceous he has made out a very different range of species, including 9 *Cycads*, 3 *Equisetaceæ*, 17 *Conifers*, 1 *Lycopod*, 5 *Monocotyledons* and 1 *Dicotyledon*, with 38 *Fucoids*.

Besides the genera above enumerated, Lesquereux has the following, exclusive of Cryptogams, in his catalogue of the groups represented. It includes, besides his own, Newberry's results.

*Pterophyllum*, of the order of Zamiæ?; *Sequoia*, *Araucaria*, *Abietites*, *Glyptostrobus*, *Phyllocladus*, *Geinitzia* of Conifers; *Arundo; Dioscorea; Flabellaria* among Palms; *Liquidambar*, *Populus*, *Populites*, *Myrica*, *Betula*, *Betulites*, *Alnus*, *Quercus*, *Celtis*, *Ficus*, *Nyssa*, *Laurus*, *Laurophyllum*, *Persea*, *Cinnamomum*, *Oreodaphne*, *Proteoides*, *Embothrium*, *Aristolochites*, *An-*

*dromeda*, *Diospyros*, *Sapotacites*, *Bumelia*, *Hedera*, *Cissites*, *Protophyllum*, *Acerites*, *Negundoides*, *Greviopsis*, *Anisophyllum*, *Celastrophyllum*, *Rhamnus*, *Juglans*, *Pyrus*, *Prunus*. The whole number of species enumerated is 130: of these, eight are of the genus *Quercus*, five, of *Populus*, six of *Plutanus*, six of *Sassafras*, five of *Magnolia*, three of *Liriodendron*, and eight of *Protophyllum*. Some of the leaves are referred with doubt to existing genera, as they embrace characters of two or more. The leaves are mostly entire, coarsely veined and coriaceous. No beds in the Rocky Mountain region older than Cretaceous contain any related species, or a single Angiosperm. The author remarks that the facts "seem to prove a collateral development of different primitive types, and therefore, the appearance at certain epochs of those original forms which, at each geological period, have changed the character of the vegetable world, and which have not any connection with antecedent types."

(4.) *Lists of Elevations principally in that portion of the United States west of the Mississippi River.* Collected and arranged by H. GANNETT, M.E. 72 pp. 8vo. Washington, 1875.—This pamphlet is the third edition of the List of Elevations issued by the Department of the Interior in connection with the publications of the U. S. Survey of the Territories. The Catalogue has been much enlarged by additions from railway levellings and other sources, and also by including the elevations of many points east of the Mississippi River. It is therefore a very important contribution to the department of North American topography.

(5.) *Meteorological Observations* made in 1873 and 1874 in Colorado and Montana, prepared by G. B. Chittenden. 58 pp. 8vo. 1875.

11. *Carte hydrologique du Department de Seine-et-Marne;* by M. DELESSE, Ingenieur-en-Chef des Mines.—This chart represents in colors and by lines of equal height above the level of the sea, the distribution of the superficial and subterranean sheets or streams of water over the Department of Seine-et-Marne, in France, and the altitude of the surface. The facts have been obtained partly by collecting all that is known of the wells of the region. The geological stratum upon which the water rests or flows over the different parts of the department, and the depths or curves of its surface, are indicated. Many interesting conclusions are arrived at, some of them of geological interest, and all of them of great value to the Department. The survey and the charts make an excellent model for the world. The charts are in the very best style of the chromo-lithographic art.

12. *Note on the genus Calamodon;* by E. D. COPE. (Communicated.)—I observe in your last number that you state, on the authority of Professor Marsh, that this genus is identical with the *Stylinodon* of Marsh, already described in your May number of the current year. If Professor Marsh's diagnosis be accurate, the genera are distinct, as the description cited ascribes six molars to *Stylinodon*, while five only exist in *Calamodon*. This I stated in

my description on p. 6 of my report on the Vertebrata of the Eocene of New Mexico.

13. *Shepherd's Pipe of the Reindeer era.*—An instrument made of the bones of birds placed together as in the shepherd's pipe, which it is supposed was used as a musical instrument, is announced by M. Piette as having been found in a deposit of the Reindeer era (Stone Age).—*Les Mondes*, Jan. 28.

14. *Lead vein in Newburyport, Mass.*—The vein of lead ore recently discovered intersecting the gneiss of Newburyport has, according to Professor R. H. Richards, a lead-bearing band against its north wall, which averages a foot in width but widens in one shaft 22 feet deep to six feet. With the galena there is a little chalcopyrite and tetrahedrite. The rest of the vein is a rusty crystalline rock free from mica, whose precise nature is not yet determined. The lead-bearing band is from one-third to one-half galena. A ton (2240 lbs.) of the crude ingot lead obtained from the ore yielded 74 ounces of silver and 341 grains of gold.—*Proc. Boston Soc. Nat. Hist.*, xvii, 200.

15. *Record of Geological Literature.*—An Annual of this title is to be commenced the coming summer by W. Whitaker of the Geological Survey Office (Jermyn st., London, S.W.). The volume will contain short abstracts or notices of Papers, Books, Maps, etc., published during the year 1874, in the departments of Geology, Paleontology and Mineralogy. It will include 200 to 300 pages and be sold for 10s. 6d. Such an Annual Record is greatly needed. Subscriptions are solicited.

16. *Composition of the native alloy of Gold and Silver in the Comstock Lode, Nevada.*—Mr. Melville Attwood, of San Francisco, in a communication to the Microscopical Society in April, 1874, describes the pale yellow alloy from the Comstock lode as occurring in similar form and composition throughout the whole length of the lode and from the croppings down to the bottom of the deepest workings. It is found occasionally in coarse pieces, but in general is finely disseminated and intimately mixed with the silver ore. It exhibits imperfect octahedral crystals and is found also in aborescent filiform masses. Hardness 3; specific gravity 12·5; after melting, 13·5 to 13·7. Color white, with a slightly yellowish tinge when freshly broken, but becomes more yellow on exposure for some time. Analysis yielded Mr. Attwood 55·37 per cent of gold, 42·87 of silver and 1·74 per cent of substances undetermined. W. P. B.

17. *Mineralogical Note;* by Albert R. Leeds, Prof. of Chemistry, Stevens Institute. *A magnesia-iron Tremolite, not asbestiform, from the soapstone quarry above Manayunk, Pa.* (Contributed by the author.)—This mineral is the *anthophyllite*, so called, given in the list of American localities on page 780 of Dana's Mineralogy, 5th edition. It occurs in a dark-colored serpentine rock, in bladed masses sometimes exceeding 1 mm. in thickness and 1 cm. in breadth in their largest part, and then thinning into fine fibers which lose themselves in the rock. These blades, with

their various alterations in size and direction, are frequently many centimeters long. They are fibrous, of vitreous luster, translucent and of slight yellow, greenish or reddish tints, derived from the serpentine and oxide of iron accompanying them. H.=2·5. Fusibility=5·5.

| | I. | II. | Mean. | O. ratio. | | |
|---|---|---|---|---|---|---|
| $SiO_2$ | 59·27 | 59·228 | 59·25 | 31·40 | 31·40 | 2·1 |
| $Al_2O_3$ | 2·45 | 2·452 | 2·45 | 1·15 | | |
| FeO | 6·50 | 6·494 | 6·49 | 1·43 | | |
| MnO | 1·09 | 1·006 | 1·05 | 0·23 | 14·93 | 1 |
| CaO | 1·72 | 1·403 | 1·57 | 0·46 | | |
| MgO | 28·30 | 28·105 | 28·16 | 11·26 | | |
| $H_2O$ | undet. | undet. | ---- | | | |
| | 99·33 | 98·69 | 98·97 | | | |

This variety of tremolite [bronzite?], it will be seen from the analysis, is distinguished by its large percentage of ferrous oxide and magnesia; and the cause of this interesting peculiarity is to be sought for in the chemical history of the magnetite-bearing serpentine in which the tremolite is imbedded.

18. *Action of light on the development of the young of Frogs.*—M. Thury took the eggs of *Rana temporaria* and placed them all under precisely the same favorable circumstances, except that while part received light through colorless glass, another part received it through green glass. The former developed rapidly, and by the end of May had a length of four centimeters, and well developed hind legs in most of them; while the latter were slowly developed, blackish in color, hardly had a length of two centimeters by the end of May, and were without a trace of the hind legs. By the 10th of June, the former had their fore legs and some were changed to frogs; the latter, still black, had no trace of legs, and breathed almost exclusively by means of their gills. By the 15th of July all the former had become frogs; but those of the latter still had no legs, and by the 2d of August they were all dead without a trace of legs having appeared. Some of the young of the latter lot transferred to the vessel of the former on the 15th of July finished their metamorphosis. At the same time some of the former transferred to the vessel containing the latter continued to develop, showing the influence of the first impulse in their development.—*L'Institut*, Dec. 23, 1874.

19. *Dimorphic Development and Alternation of Generation in the Cladocera.*—Dr. G. O. Sars has discovered a remarkable dimorphism and alternation of generation in *Leptodora hyalina*. (Om en dimorph Udvikling samt Generationsvexel hos *Leptodora*, Forhandlinger Vidensk.-Selsk., Christiania, for 1873, p. 15, and plate.) The development from the ordinary summer-eggs, as already described by E. P. Müller, is without metamorphosis and like that of ordinary Cladocera, the young when excluded from the egg agreeing essentially with the adult; while, according to Sars' observations, the young are excluded from the winter-eggs in a very imperfect condition, quite unlike the known young of

any other Cladocera, and pass through a marked post-embryonal metamorphosis. In the earliest observed stage of the young of this form, the body is obovate, wholly without segmentation, the compound eye wanting, while there is a simple eye between the bases of the antennulæ, the swimming arms (antennæ) well developed, and the six pairs of legs represented only by minute processes projecting scarcely beyond the sides of the body; but the most remarkable feature is the presence of a pair of appendages tipped with cilia and nearly as long as the body, which are evidently homologous with the mandibular palpi of other Crustaceans, although these appendages have always been supposed to be wanting in the species of Cladocera. Two subsequent stages, gradually approaching the adult form, are described. The adults from the winter-eggs have no vestige of the mandibular palpi left, yet the simple eye—which is wholly absent in ordinary individuals developed from summer-eggs—is persistent, and thus marks a distinct generation. Three stages of the young from winter-eggs are beautifully figured upon the plate accompanying the memoir.

This remarkable species has, still more recently, been made the subject of a very elaborate memoir by Prof. Weismann of Freiburg (Uber Bau und Lebenserscheinungen von *Leptodora hyalina*, Zeitschrift für wissensch. Zool., xxiv, Sept., 1874, pp. 349–418, plates 33–38), who, however, had not observed the peculiar development of the winter-eggs. The occurrence of this genus in Lake Superior is noticed in this Journal, vol. vii, p. 161, 1874.

S. I. S.

20. *Development of the European Lobster.*—Dr. Sars has also recently published, in the Proceedings of the same Society for 1874, a paper of 27 pages, illustrated by two autographic plates, on the post-embryonal development of the European lobster (*Homarus vulgaris* Edwards). He describes and figures in detail the three larval stages corresponding precisely with the first three stages which I have described in the American lobster.* Dr. Sars did not receive my papers until after a part of his memoir was printed, so that his investigations were wholly independent. In a short appendix Dr. Sars calls attention to the remarkable agreement in the results at which we had each arrived, and to the excellent opportunity afforded for a careful comparison of the early stages of these two closely allied species. Although the corresponding stages agree so closely in form and structure, they are from the first readily distinguishable by well marked specific differences in the form and armature of the appendages. In fact, the differences appear greater in the larval stages than in the adults. Dr. Sars was not able to trace the development beyond the third stage, which he had at first supposed could not be the last stage of the larva, but after comparison with the later stage of the American lobster he regards it as quite probably the last true larval stage.

S. I. S.

* This Journal, vol. iii, pp. 401–406, plate IX, June, 1872, and Transactions Connecticut Academy, vol. ii, pp. 351–381, plates XIV–XVIII, August, 1873.

21. *Cumacea from the West Indies and the South Atlantic;* by G. O. SARS. 30 pp. 4to, with 6 plates. (From the Svenska Vetenskaps-Akademiens Handlingar, Bandet xi; Stockholm, 1873.)—This memoir, in the same form as the one on the Cumacea of the Josephine Expedition previously noticed, contains minute descriptions and elaborate figures of seven species from the West Indies and from off the mouth of the La Plata. Among them there is a remarkable new genus, *Stephanomma*, in which there is a large central eye upon the front surrounded by a circle of smaller eyes.

S. I. S.

22. *Distribution of Insects in New Hampshire;* by SAMUEL H. SCUDDER. 50 pp. large 8vo, with 2 maps and a plate. (From vol. i of the Final Report upon the Geology of New Hampshire; Concord, 1874.)—Mr. Scudder first discusses the boundary between the Alleghanian and Canadian faunæ in the State and then the special relations of the alpine and sub-alpine districts of the White Mountains. He makes the Canadian fauna extend to just south of the White Mountains, while the Alleghanian fauna proper occupies only the extreme southern border, the broad intermediate space —about half the area of the State—being regarded as the "common meeting ground" of the two faunæ. These divisions and the alpine and sub-alpine districts upon the mountains are indicated by colored areas on the two maps. This introductory portion is followed by lists of the Butterflies and Orthoptera of the State, with many valuable notes on the distribution of the species, and a full account of two White Mountain butterflies, *Œneis semidea* and *Brenthis Montinus*. S. I. S.

23. *On the Cotton Worm of the Southern States, Aletia argillacea* Hübner, *a moth of the family Noctuidæ;* by A. R. GROTE. (Proc. Am. Assoc., 1874.)—After a discussion of the synonymy of the cotton worm family, Mr. Grote discusses as follows the question of the origin of the moth:

"The conclusion to which I have come with regard to the cotton worm is, *that it dies out every year* (*with its food plant*), *that it occurs in the cotton belt of the Southern States, and that its next appearance is the result of immigration.* Testimony is at hand to show that for many years after the cultivation of the cotton plant was introduced into the Southern States, the cotton worm never appeared. The date at which it first appeared in central Alabama has been differently stated to me, but it evidently but little preceded the late war. That the moth is capable of sustaining long and extended flight is readily proven. Professor Packard observed the moth off the coast of the Eastern States, as also Mr. Burgess. I have observed the moth in October in Buffalo, N. Y., as also Dr. Harvey. According to Mr. Riley, the moth has been observed in Chicago, I presume in the fall. It seems that the moth follows the coast-line northward, as also the water courses that empty into the Gulf of Mexico. It is noteworthy here that the watershed of the Ohio and Mississippi extends to within fifty miles of Buffalo. As an example of the prolonged flight of moths, I will state that I have observed in the Gulf

Stream, off the Carolinas and out of sight of land, in the month of August, large numbers of a moth, the *Agrotis annexa* of Treitschke.

Again, I have been struck by the absence of parasitic checks to the cotton worm in the south. I could never discover any, although such may exist. Spreading, as I believe it to do, as a moth, the absence of peculiar parasites to the worm may be reasonably accounted for. I have already and elsewhere pointed out, that in order to make the first brood of the cotton worm the progeny of the so-called "hibernating" individuals (as Professor Riley would suppose), a period of several months has to be accounted for, since these "hibernating" moths could not wait till midsummer to deposit their eggs; and while the cotton is young, and even before it is up, insect life is active, and the weather is warm and other vegetation fully out in the region of the South where I have lived. There is also no reason to believe that the cotton worm ever breeds in the North, and this notwithstanding Professor Riley's suggestions to the contrary, in the Sixth Report before mentioned. The worm never has been noticed on any other plant than the cotton, and in the South perishes by thousands rather than eat any other. The habit of wandering in masses when food fails is a proof of this, as while the worm is supplied with cotton leaf it never quits the plant, transforming to the chrysalis on the stalk which has furnished it nutriment. The wandering habit is not normal but accidental, and the worm is not "gregarious" like the "tent caterpillar." Its "hibernation" with us must also be regarded as accidental, or at least as barren of results. For when spring comes the *Aletia argillacea* has vanished, and is not to be found with the hibernating species of Lepidoptera, renewedly active. And if it *were* found in February and March, it would find no cotton plants upon which to deposit its eggs. If oviposition ever takes place in these months in the cotton belt, the young cotton, free from worms, disproves its efficacy.

It is possible that in the southern portions of Texas, or the Floridian peninsula, the Aletia may sustain itself during the entire year; I have no means of information on this point. My observations are made on its occurrence over the central and principal portions of the cotton belt, and into which I believe it to be imported *de novo* every season that it occurs and from more southern regions.

I conclude, therefore, that while the cotton plant is not indigenous to the Southern States (where it becomes an annual), the cotton-worm moth may be considered not a denizen, but a visitant, brought by various causes to breed in a strange region, and that it naturally dies out with us in the cotton belt, unable to suit itself *as yet* to the altered economy of its food plant and to contend with the changes of the seasons.

When this fact is comprehended, it will simplify the process of artificial extermination by limiting the period during which we can successfully attack the cotton worm, and by doing away with a certain class of proposed remedies.

From the foregoing it will be evident that, 1, The artificial agent employed to destroy the cotton worm must be employed against the first brood as it appears in any given locality during the progression of the moth northward; and, 2, that, in order to be effectual, a concerted action in the application of the remedial agent in any given locality will be found necessary.

I also recommend the introduction of the English sparrow into the Southern States, and additional legal protection to insectivorous birds. Since the war there has been too much ignorant use of the gun on the part of the negroes. *All* the birds should be protected as much as possible, for many species not usually considered insectivorous are yet found, during certain seasons of the year, to live on insects."

## III. Astronomy.

1. *The Transit of Venus, Dec.* 8, 1874.—The following additional information respecting the late transit has been received since the publication of the last No. of the Journal. The stations are arranged in the order of latitude:

### *In the Northern hemisphere.*

1. *Vladivostok.* Lat. 43° 7′, long. 8h. 47m. E. Prof. Asaph Hall, of the U. S. Naval Observatory, had charge of the American station at Vladivostok. The first contact was pretty well observed, but the haze was so thick as to render it impossible to take photographs at that moment. The time of second contact was noted with accuracy, and some photographs were taken that were tolerably satisfactory. The duration of the transit was 4h. 45m., during which period the haze dispersed three times, allowing the photographers to get some excellent pictures. The time of third contact was pretty accurately noted, but at the moment of fourth contact Venus was entirely invisible. Thirteen photographs were taken and the exact time of each was noted. Some of these are well defined, but others are faint and of uncertain value.
2. *Pekin.* Lat. 39° 54′, long. 7h. 46m. E. At the French station the four contacts were observed as follows: first 21h. 32m. 42s.; second 22h.; third 1h. 50m. 15s.; fourth 2h. 17m. 13s. Also sixty good photographs were taken.
3. *Yokohama.* Lat. 35° 36′, long. 9h. 19m. E. Russian station. Two contacts were observed, and sixty pictures taken. The Mexican party at Yokohama observed all the contacts and took a large number of pictures.
4. *Beyrout.* Lat. 33° 49′, long. 2h. 21m. E. Observations successful.
5. *Nagasaki.* Lat. 32° 45′, long. 8h. 39m. E. The American observations at this station were under the direction of George Davidson of the U. S. Coast Survey. The first contact could not be satisfactorily observed on account of clouds. The second contact was well observed. The separation of the limbs was then observed, until Venus had advanced one diameter, and then measures of the diameter of the planet were made. The third contact could not be satisfactorily observed on account of clouds, and at the time of fourth contact the sun was entirely obscured by clouds. The meridian transit of the sun's first limb was observed over nine threads, the first limb of Venus over eight threads, the second limb of Venus over eight threads, and the second limb of the sun over six threads. The difference of declination of the upper limb of the sun and both limbs of Venus was measured by eighteen micrometer readings. The first and second contacts occurred about 1m. 45s. later than the American Almanac computations, and about 3m. 30s. later than the English computations. The third contact occurred near the time of the American computations.

6. *Calcutta.* Lat. 22° 35′, long. 5h. 54m. E. Observations excellent.
7. *Maddapore.* Lat. 12° 48′ (?), long. 5h. 6m. E. Italian station. The four contacts were all observed.
8. *Colombo.* Lat. 7° 0′, long. 5h. 20m. E. All the contacts observed except the first.

*In the Southern hemisphere.*

1. *Rodrigues.* Lat. 19° 4′, long. 4h. 14m. E. Ingress and egress were well observed, and 58 photographs taken.
2. *Mauritius.* Lat. 20° 20′, long. 3h. 51m. E. Station of Lord Lindsay. All the contacts were observed, except the first, and 110 good photographs were taken.
3. *Reunion.* Lat. 20° 51′, long. 3h. 42m. E. Dutch station. Third contact observed and a few photographs taken.
4. *New Caledonia.* Lat. 21°, long. 11h. E. French station. Second contact observed and 100 good photographs taken.
5. *Cape Town.* Lat. 33° 55′, long 1h. 13m. E. Fourteen photographs taken.
6. *Queenstown, Otago.* Lat. 45° 50′, long. 11h. 20m. E. American station. The observations at this station were under the direction of Prof. C. H. F. Peters of Hamilton College. The sky was overcast until two minutes before the first contact, when the sun shone out and continued bright for nearly two hours. The distance of Venus from the sun's limb was repeatedly measured, as also the apparent diameter of Venus. During the latter part of the transit, floating clouds interfered, but 239 photographs were taken.

E. L.

2. *Observations on the Transit of Venus at Nagasaki;* by Professor Davidson. (Extract from a letter by Mrs. Davidson,* dated Nagasaki, Dec. 10th, 1874.)— . . . The preceding night was clear and beautiful until daybreak, when clouds began rapidly to form, breaking away again about $8\frac{1}{2}^h$ and again clouding over by $9\frac{1}{2}^h$. * * I was to record for my husband, who seemed calm and in good spirits notwithstanding the doubtful weather. We were all at our posts of duty by ten o'clock, and as the time drew near you can imagine our suspense. In my husband's observatory (that of the large equatorial), just before the computing time, the sun seemed to be breaking through the clouds, and all was in readiness. George, our eldest boy, holding the chronometers up to his father's eye and ear, and I (seated where I could see my husband's face), with book and pencil in hand, with closed doors and perfect stillness, save the regular beats of the clock and chronometer. It was almost a solemn moment. The sun broke forth with one gleam. I was almost startled to my feet with the shout of "*commence*" given by my husband, as a warning to the photographers that the instant was about to arrive. In a few seconds he gave an exclamation of delight, and the first contact was accomplished and duly recorded. Observations were kept up until the next critical moment, of the second contact—the sun growing less bright but still bright enough for observations. The second contact was seen and, further observations made as the body was passing over the sun. Clouds grew thicker, leaving scarcely a hope for the third contact and also for the fourth, which were not visible, and then the whole thing was over. * * * The exact spot on the sun's limb where the contact should appear was only known by

* We are indebted for this letter to Mr. Daniel B. Smith of Germantown, Pa.

computation from previous data; and under so large a magnifying power, which took in about 5½ diameters of Venus, an error of one minute of an arc would have been fatal. Mr. Davidson had gone over his calculations several times, and that same morning had revised them again to satisfy himself, then pointed his instruments, and sure enough there came Venus right in the center of his pointing, 3½ minutes later than the English computed time, and 1½ earlier than the American time.

## IV. Miscellaneous Scientific Intelligence.

1. *Canadian Scientific Research in* 1874.—Mr. James Richardson (of the Geological Survey) spent the months of May, June and July in a topographical and geological examination of the inlets on the coast of British Columbia, between the 52d and 55th degrees of north latitude. * * *

Mr. George M. Dawson, geologist and botanist to the Boundary Commission, has been engaged in continuing the examination of the region in the vicinity of the 49th parallel. The work of this season extended from Woody Mountain, which is about 400 miles west of the Red River, to the watershed of the continent in the Rocky Mountains. The part of the journey from Red River to Woody Mountain lay over ground already explored in 1873, and but little of geological interest was met with. Woody Mountain, so-called, is situated on the northern edge of the plateau of the Lignite Tertiary, and from the existence of groves of poplars in the valleys, has been chosen by the half-breeds as a base for their hunting and trading expeditions. South of Woody Mountain, on the boundary line, excellent sections illustrating the junction of the Cretaceous and Lignite Tertiary were found, in which the base of the latter formation was well defined. Denudation acting on the little consolidated clays of the Tertiary, has converted a portion of the region where it occurs into *Bad Lands*, which, though perhaps not so rugged as those of Southern Dakota, are characterized by barren clay hills and gorges with scarcely a trace of verdure, and are sufficiently forbidding. Westward from Woody Mountain the Cretaceous rocks cover the greatest area, but those of the base of the Tertiary frequently appear resting on them, and almost always produce a more or less well marked plateau, the general aspect of the country being comparable to that of a cameo, the depressed parts of which are based on the dark Cretaceous clays. The Cretaceous rocks in some places yielded numerous well-preserved fossils enclosed in ferruginous or calcareous nodules, the play of color due to the original pearly matter of the shell being in many cases still apparent. The horizon indicated by most of these is that of the Fort Pierre Group or Cretaceous No. 4 of Meek and Hayden. . . .

The field work of the Boundary Commission is now over, the line having been run and properly marked from the Lake of the

Woods to the Watershed of the Mountains, where it joins that previously surveyed from the Pacific coast. The maps and detailed reports in the various departments are in course of preparation.

Professor Bell has been again engaged during the past summer in the Northwest Territories. The region more particularly explored was the high grounds extending along the western sides of Lakes Manitoba and Winnipegosis and comprising the Riding, Duck and Porcupine Mountains. The valleys of the Swan River and of the Upper Assinniboine were carefully examined, as were also those of some of their tributaries. Mr. Bell and his assistants likewise visited portions of the shore of all the lakes of the Winnipeg basin.—J. F. W. *Montreal Gazette*, Jan. 15.

2. *British Arctic Expedition.*—The scientific part of the forthcoming Polar Expedition will not fail through want of advice and instruction, for while the Geographical Society are preparing their promised Manual of Geography and Physical Geography, the Royal Society are getting ready a Manual of Physical and Natural Sciences. Thus the explorers may prepare themselves for observations on magnetism, on meteorology, on the tides, which in the Arctic zone are peculiar, on geology and botany, on natural history, particularly that part of it which includes the minor forms of marine life; and last, though not least, ethnology is to be attended to, as opportunity may offer. This is a good scheme; almost too good, for opportunities can hardly be other than rare, especially in the ethnic system, in the frozen and desolate regions around the Pole. The Admiralty have relaxed their original intention to appoint none but naval men as scientific observers, and the Council of the Royal Society have recommended for appointment as naturalists to the Expedition, Capt. Feilden, R.A. (at present in Malta) and Mr. Chichester Hart, of Dublin. Hence we may conclude that in the persons of these two gentlemen botany and zoology are provided for. Meanwhile the naval preparations are actively carried on; the two vessels selected for the Expedition, the Alert and the Bloodhound, are being strengthened with all possible dispatch, and the victualling department is busy in cooking and concentrating provisions of the best kind into the smallest possible space.—*Athenæum, Jan.* 30.

3. *Introduction to the Resources of Tennessee;* by J. B. Killebrew, A.M., assisted by J. M. Safford, Ph.D., M.D., and others, being the First and Second Reports of the State Bureau of Agriculture; with five maps, one geologically colored. 1193 pp. 12mo. Nashville, 1874.—The State of Tennessee has an unusually wide range of climates, elevations, geological formations and vegetable productions. The Report now before us is therefore of more than usual interest, and gives the distinctive characters of a much larger area than its title would imply. On the east its border mountains have the same characters as adjoining portions of North Carolina, Virginia and Georgia; its great valley graduates upward into Virginia and downward into Georgia; the coal and iron-ore resources of the slopes of the Cumberland

Mountains and the mild equable climate of the summit plateau are continuous with those of West Virginia, Kentucky and Alabama; its central basin has the same rich "blue-grass" soil as that of Kentucky; and its western border includes a large area of the Mississippi bottoms. The work opens with a brief description of the Topographical Features and Natural Divisions, Climate and Geological Formations, followed by chapters upon Farm-Geology, Soils, Timber, Farm Products, Grasses, Live Stock, Dairy Products, Grapes, Honey, Coal, Iron, Copper, Transportation, Schools, etc., and these by others giving the details of each county separately. The volume makes a grand exhibit of the resources of the State, and will probably many times repay the cost of its publication, through the population and capital which it will be the means of attracting thither.

To make this Report quite complete it should be supplemented by full details as to the geological structure of each county, such as would be obtained in a careful geological survey. It is much to be desired that the survey, begun and so well carried forward by Professor Safford for several years before the war, should be revived on a larger scale and finished.

4. *The Microscope and its Revelations*; by Wm. B. Carpenter. Fifth edition, with 25 plates and 449 wood-cuts. Philadelphia, 1875. (Lindsay & Blakiston.)—This is an enlarged and revised edition of Dr. Carpenter's well known work on the microscope. Considerable additions have been made to the chapters relating to microscopes and the accessory apparatus. But more numerous and perhaps more important additions have been made to the portions relating to the structure of the lower forms of animals and plants, especially the Foraminifera, Bathybius, Coccoliths, Bacteria, Diatoms, etc., including many of the recent discoveries made in connection with the deep-sea dredgings. v.

5. *Mt. Katahdin.*—Through a very careful barometrical determination in August, 1874, Prof. N. C. Fernald has ascertained the height of Mount Katahdin above mean tide at Bangor, Maine, to be 5,215·5 feet, with the probable error not exceeding 4·2 feet.

### OBITUARY.

D'Omalius d'Halloy.—This eminent Belgian geologist, an active member of the Geological Society of France, died at Brussels, on the 15th of January, aged nearly ninety-two years.

Sir Charles Lyell.—Sir Charles Lyell died on the 22nd of February, aged seventy-eight years.

Annual Report upon the Survey of the Northern and Northeastern States, in charge of C. B. Comstock, Major of Engineers, Bvt. Brig. General, U. S. A., being Appendix CC to the Annual Report of the Chief of Engineers for 1874. 78 pp. 8vo. Washington, 1874.

Report of Progress of the Geological Survey of Canada, for 1873–74, Alfred C. Selwyn, F.R.S. 270 pp. 8vo. Montreal, 1874.

# APPENDIX.

## Art. XXVI.—*Notice of New Tertiary Mammals*, IV; by O. C. Marsh.

The remains described in the present communication include some new forms of Quadrumana from the Eocene and Miocene; a species of the new order *Tillodontia*, recently established by the writer; the first horned Rhinoceroses found in this country; a new genus of the *Brontotheridæ;* and a number of other extinct mammals from the Tertiary of the Rocky Mountain region and the Pacific coast. The specimens described are all preserved in the Museum of Yale College.

*Lemuravus distans*, gen. et sp. nov.

The first announcement of the order *Primates* from the Tertiary of this country was published by the writer, Oct. 8th, 1872, and subsequently appeared in this Journal, (vol. v, p. 405, Nov., 1872). In this paper, three genera of the *Limnotheridæ*, viz: *Limnotherium*, *Thinolestes* and *Telmatolestes*, previously described by the writer, were shown to belong to the lower Quadrumana, the principal parts of the skeleton being very similar to those of Lemurs, while the jaws were somewhat like those of Marmosets. The number of teeth was stated to be greater than in any known forms of the order. Subsequent researches have fully confirmed this determination, and many new facts may now be added in regard to the characters and affinities of this well marked group. From numerous specimens, the writer has ascertained that the *Limnotheridæ* should be placed in the *Prosimiæ*. The brain was nearly smooth, and the cerebellum large, and placed mainly behind the cerebrum. The orbits are open behind, and the lachrymal foramen is outside the orbit.

In addition to the genera mentioned above, an examination of the type specimens of *Notharctos*, *Hipposyus*, *Microsyops*, and *Palæacodon* of Leidy shows that they are true Primates, and probably all belong to the *Limnotheridæ*. To these may be added *Mesacodon*, *Bathrodon*, and *Antiacodon*, described by the writer.*

The genus *Lemuravus*, here described, is nearly related to *Hyopsodus* Leidy. The latter proves on investigation to belong to the *Primates*, and not to the Ungulates. This is shown by

* *Antiacodon nanus* Marsh was redescribed by Cope, several months later, under the name *Anaptomorphus æmulus*. *Limnotherium affine* Marsh was likewise redescribed by the same author as *Tomitherium rostratum* Cope.

the close correspondence of the skeleton with that of the Lemurs, and by the general structure of the skull. *Hyopsodus* and the present genus represent a distinct family, which may be called *Lemuravidæ*. The type genus, *Lemuravus*, has 44 teeth, indicating the most generalized form of the order. *Hyopsodus* has apparently but 42. In the former, the teeth form a continuous series above and below. The canines are small, and the upper incisors are not separated on the median line, as in Lemurs. The molar teeth appear to be essentially the same as those of *Hyopsodus*, but as the latter are only known with certainty from the lower jaw first described there may be important differences. The symphysis of the lower jaw is completely coössified. The brain was nearly smooth, and of moderate size. The skeleton most resembles that of the Lemurs. The humerus has at its distal end a supracondylar foramen, and a supratrochlear perforation. The radius and ulna are distinct. The femur has a small pit in the head for the round ligament. Its distal end is more flattened antero-posteriorly than in the Lemurs. The tibia and fibula are separate. The astragalus is very similar to that of *Lemur*.

*Measurements.*

| | |
|---|---|
| Space occupied by entire upper dental series, | 30· mm. |
| Extent of upper molar series, | 21·5 |
| Extent of three upper true molars, | 11· |
| Extent of three upper incisors, | 5·5 |
| Extent of lower molar series, | 23· |
| Extent of three lower true molars, | 12·5 |
| Diameter of head of femur, | 5· |
| Transverse diameter of distal end of femur, | 10· |
| Transverse diameter of proximal end of tibia, | 9· |
| Transverse diameter of distal end, | 5·5 |
| Length of astragalus, | 7·5 |

The present species was about the size of the largest squirrels. The type specimen was found in 1871, in the Lower Eocene of Wyoming, by Mr. T. G. Peck of the Yale party.

*Laopithecus robustus*, gen. et sp. nov.

Among the interesting specimens obtained by the writer during his late expedition to the "Bad Lands" in Nebraska was the lower jaw of a monkey, the first of the order found in that region. The specimen is well preserved, and indicates an animal about as large as a Coati. The crowns of the molar teeth agree essentially with those of some South American monkeys, but still more nearly with those of the Eocene *Limnotheridæ*. From that family the present genus may readily be distinguished by the first true molar, which is the largest of

the series, much larger than the penultimate. The last lower molar is smaller than the others. In the first and second true molars, the external cusps are slightly in advance of the corresponding inner ones. The anterior pair are higher and nearer together than those behind. A low ridge extends obliquely from the base of the anterior inner cone to the summit of the outer posterior cusp. The inner posterior cusp is smaller than the others, and separated from them. The crowns are bounded by a distinct basal ridge, except on the inner side. The enamel of the molars is rugose.

*Measurements.*

| | |
|---|---|
| Space occupied by three lower true molars, | 17·mm· |
| Antero-posterior diameter of first lower molar, | 7· |
| Transverse diameter, | 6· |
| Height of crown, | 5·5 |
| Antero-posterior diameter of penultimate molar, | 5·5 |
| Transverse diameter, | 5· |
| Height of crown, | 4·2 |
| Depth of jaw below first lower molar, | 12·6 |

This specimen was found in the *Oreodon* horizon of the Miocene "Bad Lands," about thirty miles south of the Black Hills.

*Tillotherium fodiens*, sp. nov.

Since this genus was proposed by the writer (this Journal, v, p. 485, June, 1873), much light has been thrown upon its affinities by additional remains. It proves to be quite distinct from *Anchippodus* (*Trogosus*) Leidy, although nearly related. The latter genus, unfortunately, is known only from portions of the lower jaw, but this shows marked differences from *Tillotherium*, which lacks the inner pair of small lower incisors, and has an incisor and a canine between the large scalpriform tooth and the first lower premolar. *Tillotherium* has 34 teeth in its permanent dentition (p. 221), and the molar teeth most resemble those in Ungulates. The upper true molars are similar to the premolars of some Eocene Perissodactyls, but are somewhat like the tubercular molars of the *Canidæ*. The lower molar series is of the *Palæotherium* type, and the last lower molar has a well developed posterior lobe.

In the present species, the canines were small, and the superior ones placed somewhat behind the premaxillary suture. The five digits on each foot were all well developed, and of moderate length. The metapodial bones are similar to those in *Ursus Americanus*, but the ungual phalanges preserved are more oblique, and less pointed at the extremity.

*Measurements.*

| | |
|---|---|
| Length of skull, from front of incisors to end of occipital condyles, | 355· mm. |
| Extent of entire upper dental series, | 186· |
| Extent of upper molar series, | 98· |
| Extent of three true molars, | 59· |
| Antero-posterior diameter of penultimate upper molar, | 20·5 |
| Transverse diameter (greatest), | 35· |
| Antero-posterior diameter of last upper premolar, | 12· |
| Transverse diameter, | 24· |
| Antero-posterior diameter of base of gliriform upper incisor, | 22· |
| Transverse diameter, | 16·5 |
| Distance between bases of upper canines, | 35· |
| Extent of lower dental series, | 162· |
| Extent of last three lower molars, | 70· |
| Extent of entire lower molar series, | 93· |
| Antero-posterior diameter of lower gliriform incisor, | 21· |
| Transverse diameter, | 15· |
| Transverse diameter of condyle of lower jaw, | 52· |
| Length of radius, | 170· |
| Transverse diameter of humerus at distal end, | 76· |
| Transverse diameter of tibia at proximal end, | 59· |
| Length of calcaneum, | 72· |
| Length of first metacarpal, | 40· |
| Length of second metatarsal, | 46· |
| Length of ungual phalanx, | 35· |
| Width of articular face, | 12·5 |
| Vertical diameter, | 14· |

The remains here described indicate an animal about two-thirds as large as a Tapir. They are from the *Dinoceras* beds of the Eocene of Wyoming. *Anchippodus minor* Marsh (*Trogosus castoridens* Leidy) is from a lower horizon of the same formation. Both belong to the order *Tillodontia*.

*Diceratherium armatum*, gen. et sp. nov.

The present genus is of special interest, as it includes the first extinct rhinoceroses with horns found in America. It is an interesting fact, likewise, that these had each a pair of horns placed transversely, as in modern Ruminants, although the discovery of *Dinoceras* and *Brontotherium* has rendered this feature less unexpected. The existence of these horns is clearly indicated by large osseous protuberances on the anterior portion of the nasal bones. The latter are massive and firmly coössified, evidently to support well developed horns. The remainder of the skull, and the teeth, as well as the skeleton, so far as known, resemble the corresponding parts in *Aceratherium*. The dental formula appears to be,

$$\text{Incisors } \frac{1}{2},\ \text{canines } \frac{0}{0},\ \text{premolars } \frac{4}{3},\ \text{molars } \frac{3}{3}.$$

In the present species the skull is of moderate length. The horn-cores are oval in outline, and placed directly opposite each other on the free portion of the nasals, a short distance back from the extremity. They are directed upward and outward, and their surface is rugose. The orbit is small, and there is a prominent postorbital process on the frontal. The premaxillaries are slender, and each supports a single incisor, with a compressed crown. The molar teeth are large, and without cement. The posterior nares terminate in front of the penultimate upper molar. There is a large rounded tubercle on the supraoccipital, just above the foramen magnum. The bones of the limbs preserved indicate that there were four digits in the manus, and three in the pes.

*Measurements.*

| | |
|---|---|
| Distance from front of first premolar to end of occipital condyles, | 456· mm. |
| Distance from front of orbit to anterior narial opening, | 133· |
| Extent of upper molar series, | 256· |
| Extent of upper premolar series, | 121· |
| Antero-posterior diameter of last upper molar, | 41· |
| Transverse diameter, | 50· |
| Antero posterior diameter of penultimate upper molar, | 49· |
| Transverse diameter, | 55· |
| Antero-posterior diameter of last upper premolar, | 35· |
| Transverse diameter, | 50· |
| Antero-posterior diameter of first upper premolar, | 25· |
| Transverse diameter, | 25· |
| Width of palate between first upper premolars, | 43· |
| Width between penultimate upper molars, | 69· |
| Length of third metacarpal, | 190· |
| Width of proximal end, | 50· |
| Length of first phalanx of third digit of manus, | 31· |
| Transverse diameter of unciform, | 60· |
| Vertical diameter, | 45· |

The known remains of the present species indicate an animal about two-thirds the size of the Indian Rhinoceros. They are from the Miocene beds, near the John Day River, in Eastern Oregon.

*Diceratherium nanum*, sp. nov.

A second species of the above genus is indicated by the greater part of a skull and teeth, and some other remains. These specimens pertained to an animal scarcely more than one-half the bulk of that last described. The horn-cores are more compressed, and the extremity of the nasals in front of them is pointed. The anterior narial opening is large. The premaxillaries are slender and compressed. They do not extend so far forward as the nasals.

*Measurements.*

| | |
|---|---|
| Distance (approximate) from front of first premolar to postorbital process, | 155· mm. |
| Distance from end of premaxillary to first upper premolar, | 91· |
| Antero-posterior diameter of upper incisor, | 25· |
| Transverse diameter, | 11· |
| Antero-posterior diameter of first lower premolar, | 24· |
| Transverse diameter, | 14· |
| Antero-posterior diameter of second premolar, | 26· |
| Tranverse diameter, | 18· |

The geological horizon and locality are essentially the same as in the last species.

*Diceratherium advenum*, sp. nov.

A species clearly belonging to the Rhinoceros family, and possibly to the same genus as the preceding, is indicated by a few fragmentary remains, which are of interest from their geological horizon and locality. The most perfect of these specimens is a last upper molar, and the corresponding lower molar. The former has a wide sigmoid valley between high and nearly parallel transverse crests. There is a strong anterior and posterior basal ridge, but only a faint trace on the inner side near the bottom of the valley. The enamel of the outer and posterior faces especially is marked by delicate vertical striæ. The lower molar has a high narrow crown. The enamel is rugosely striate.

*Measurements.*

| | |
|---|---|
| Greatest antero-posterior diameter of last upper molar, | 40· mm. |
| Transverse diameter (approximate), | 42· |
| Depth of transverse valley, | 19· |
| Antero-posterior diameter of last lower molar, | 40· |
| Transverse diameter, | 19· |
| Height of unworn posterior crest, | 22· |

The known remains of this species pertained to an animal half the bulk of the Indian Rhinoceros. The main interest attached to them is the fact that they were found with upper Eocene fossils, in Utah, and are the first indications of this group in that region. Possibly the strata containing these fossils may in part prove to be lower Miocene.

A comparison of the Lophiodont genus *Hyrachyus* with the Miocene Rhinoceroses, especially *Hyracodon*, seems to point to the former as the Lower Eocene representative or ancestor of the latter group. The skull and teeth of *Hyrachyus* are so similar to those of *Hyracodon* that only slight changes are necessary to transform one into the other. The skeletons, too, are much alike, but *Hyracodon* has only a rudiment of the fifth

metacarpal, and hence the line of descent for the four-toed forms was probably a different one.

### *Brontotheridæ.*

During a recent expedition to the "Bad Lands" of Dakota, the writer secured a large number of specimens belonging to the *Brontotheridæ*, most of them in good preservation. From the Miocene of Colorado, explored by the writer in 1870, and subsequently, a large amount of similar material has been obtained, so that at the present time the Yale Museum contains portions of more than 100 different individuals of this family. A study of these specimens, in connection with the types originally discribed, promises to leave but few points in doubt in regard to the structure or affinities of the group. The results will be published at an early day, but a few are given here, which may clear up some of the existing confusion about the different genera.

It may now be regarded as established that all the species of the *Brontotheridæ* had horns, and there is no reasonable doubt that these were common to both sexes. The osseous horn-cores in each species varied much in size and shape with difference of age, and probably of sex. The incisors are small, and in old specimens are frequently lost.

There appear to be four well marked genera in this family now known, which may be distinguished as follows:

1. *Titanotherium* Leidy (*Menodus* Pomel.)

Dentition $=$Incisors $\frac{2}{2}$; canines $\frac{1}{1}$; premolars $\frac{4}{4?}$; molars $\frac{3}{3}$.

Diastema behind upper canines. Basal ridge on inner side of upper premolars not continuous. Nasals short. A postorbital process. Third trochanter rudimentary or wanting. Type *T. Proutii* Leidy.

2. *Megacerops* Leidy. (*Megaceratops* Cope), (*Symborodon* Cope in part.)

Dentition $=$Incisors $\frac{2}{0}$; canines $\frac{1}{1}$; premolars $\frac{4}{3}$; molars $\frac{3}{3}$.

Diastema behind upper canine. Inner basal ridge on upper premolars not continuous. Nasals more elongated. A postorbital process. Third trochanter rudimentary or wanting. Type *Megacerops coloradensis* Leidy.

3. *Brontotherium* Marsh. (*Symborodon* Cope, in part.) (*Miobasileus* Cope.)

Dentition $=$Incisors $\frac{2}{2}$; canines $\frac{1}{1}$; premolars $\frac{4}{3}$; molars $\frac{3}{3}$.

No superior diastema. Strong continuous basal ridge on inner

side of upper premolars. No postorbital process. Third trochanter distinct. Type *B. gigas* Marsh.

4. *Anisacodon* Marsh, gen. nov.

Dentition $= \text{Incisors } \frac{0}{1}$; canines $\frac{1}{1}$; premolars $\frac{4}{3}$; molars $\frac{3}{3}$.

No superior diastema. Strong inner basal ridge on upper premolars. Last upper molar with two inner cones. No postorbital process. Type *A. montanus* Marsh.

*Anisacodon montanus*, sp. nov.

This species is especially distinguished by the emargination of the extremity of the nasals; the short premaxillaries; and the rectangular form of the last upper molar. The inner posterior cone of this molar is smaller than the one in front, and quite distinct from the posterior basal ridge.

*Measurements.*

| | |
|---|---|
| Extension of premaxillaries in front of canines, | 15· mm. |
| Distance from end of premaxillaries to narial aperture, | 76· |
| Width of nasals above end of premaxillaries, | 95· |
| Antero-posterior diameter of last upper premolar, | 43· |
| Transverse diameter, | 63· |
| Antero-posterior diameter of penultimate upper molar, | 77· |
| Transverse diameter, | 85· |
| Antero-posterior diameter of last upper molar, | 84· |
| Transverse diameter, | 88· |

The specimen here described was found by the writer in November last, in the Miocene of northern Nebraska.

*Diplacodon elatus*, gen. et sp. nov.

The genus here established presents characters in some respects intermediate between *Limnohyus* and *Brontotherium*. It agrees with the former in its complete dentition (44 teeth), and in the general form of the incisors, canines, and true molars. It resembles the latter still more closely in the premolar and molar teeth, and parts of the skeleton, especially in the vertebræ, and bones of the extremities. From the Eocene *Limnohydiæ*, already described, this genus is sharply distinguished by the last upper premolar, which has two distinct inner cones, thus agreeing essentially with the first true molar. This character, which has suggested the name of the genus, is one step toward the modern type of Perissodactyl dentition. The dental formula of the genus is the same as *Limnohyus*, viz:

$$\text{Incisors } \frac{3}{3}, \text{ canines } \frac{1}{1}, \text{ premolars } \frac{4}{4}, \text{ molars } \frac{3}{3}.$$

In other respects the teeth most resemble those of the *Bron-*

*totheridæ*. From this family, *Diplacodon* differs widely in its dentition, and the absence of horns.

The cervical vertebræ are short, and opisthocœlous. The radius and ulna, and tibia and fibula, are distinct, and the feet show well marked Perissodactyl characters. There were four digits in front, and apparently three behind.

In the present species, the incisors are all well developed, and those in the lower jaw are directed forward. The canines are large, and have long curved crowns with pointed extremities. The first three upper premolars have the two inner cones connate. The upper true molars are surprisingly like those of *Brontotherium*.

*Measurements.*

| | |
|---|---|
| Extent of upper molar series, | 242 mm. |
| Extent of upper true molars, | 152 |
| Antero-posterior diameter of first upper premolar, | 14 |
| Antero-posterior diameter of second upper premolar, | 21 |
| Transverse diameter, | 23 |
| Antero-posterior diameter of fourth upper premolar, | 28 |
| Transverse diameter, | 34 |
| Antero-posterior diameter of first upper true molar, | 42 |
| Transverse diameter, | 57 |
| Antero-posterior diameter of second upper molar, | 52 |
| Transverse diameter, | 57 |
| Antero-posterior diameter of last upper molar, | 60 |
| Transverse diameter, | 59 |
| Width of palate between posterior molars, | 92 |
| Distance between bases of canines of lower jaw (2d specimen) | 46 |
| Antero-posterior diameter of canine, at base, | 32 |
| Transverse diameter, | 28 |
| Height of crown, | 27 |
| Antero-posterior diameter of first lower premolar, | 17 |
| Transverse diameter, | 10 |
| Antero-posterior diameter of second premolar, | 26 |
| Transverse diameter, in front, | 15 |
| Antero-posterior diameter of third premolar, | 28 |
| Transverse diameter, in front, | 17 |
| Transverse diameter, posteriorly, | 20 |
| Length of median cervical vertebra, | 45 |
| Transverse diameter of anterior articular face, | 60 |
| Vertical diameter, | 63 |

The remains here described belonged to an animal nearly as large as a rhinoceros. They are from the Upper Eocene beds of Utah.

*Orohippus Uintensis*, sp. nov.

The present species is the largest of the genus, and in some respects indicates a transition between the lower Eocene species and the allied forms in the Miocene. It agrees with the known

species of the genus in the number and general structure of the teeth, and in the absence of the posterior intermediate lobe of the upper molars, and especially in the presence of the fifth digit in the manus. It differs in the much deeper transverse valleys of the upper molars, and in their wider crowns. The outer faces of the external cusps of the upper molars have a strong crest extending from the basal ridge to the apex.

*Measurements.*

| | |
|---|---|
| Antero-posterior diameter of penultimate upper molar, | 9·mm. |
| Greatest transverse diameter, | 12· |
| Extent of lower molar series, | 48· |
| Extent of lower premolar series, | 28· |
| Antero-posterior diameter of last lower premolar, | 8·5 |
| Transverse diameter, | 6· |
| Depth of jaw below third lower premolar, | 14· |

This species occurs in the upper Eocene deposits of Utah.

*Mesohippus*, gen. nov.

This genus presents characters intermediate between *Orohippus** Marsh, and *Anchitherium* von Meyer. The skull and teeth are very similar to those of the latter genus, and the dental formula is the same. In the feet, however, the lateral digits are larger; the fifth metacarpal is represented by an elongated splint bone; and the second and third cuneiform bones of the pes are not coossified. The type of the genus is *Mesohippus Bairdi*, = *Anchitherium Bairdi* Leidy. *Mesohippus celer*, = *Anchitherium celer* Marsh, is a smaller species. Both are from the Miocene.

*Thinohyus lentus*, gen. et sp. nov.

This genus is nearly related to *Dicotyles*, and apparently represents an earlier form of the same type. This is shown in the similar structure of the skull, and form of the teeth. The most noteworthy differences seen in the remains under description are, an additional premolar in the lower jaw, and the extension of the posterior nares between the last upper molars. The orbit is not enclosed behind, and there is no antorbital fossa. The brain was small—less than one-half the size of that of a *Dicotyles* of the same bulk—and much convoluted. There is a strong bony tentorial ridge. The molar teeth have the principal cusps more isolated than in *Dicotyles*, and the intermediate lobes larger.

In the present species the temporal fossæ are separated above only by a narrow ridge. The auditory bullæ are large, and oval in outline. The nasal bones are broad posteriorly. The

* In several recent publications, Prof. Cope has referred the genus *Orohippus* to *Hipposyus* Leidy. The two, however, as shown by a comparison of the type specimens, have no affinity, the latter belonging to the Quadrumana.

postorbital process on the frontal is longer than in *Dicotyles*, and more pointed. There is a strong cingulum on the upper molars, excepting on the base of the inner cones.

*Measurements.*

| | |
|---|---|
| Distance from fronto-nasal suture to inion, on median line, | 97· mm. |
| Distance between orbits, over frontals, | 64· |
| Expanse of zygomatic arches, | 95· |
| Extent of last three upper molars, | 43· |
| Antero-posterior of first upper true molar, | 14· |
| Transverse diameter, | 14· |
| Antero-posterior diameter of second molar, | 16· |
| Transverse diameter, | 14· |
| Width between auditory bullæ, | 9· |
| Antero-posterior diameter of auditory bulla, | 24· |
| Transverse diameter, | 18· |
| Length of symphysis of lower jaw (second specimen), | 54· |
| Distance between lower canines, | 13· |
| Space between lower canines and first premolar, | 8· |
| Space between first and second lower premolars, | 10· |

The present species was somewhat larger than the *Dicotyles torquatus*. The remains here described are from the Miocene, of the John Day River, in Oregon.

*Thinohyus socialis*, sp. nov.

A second species of the same genus, about half as large as the preceding, is indicated by some fragmentary remains, and particularly by some portions of upper jaws with teeth in excellent preservation. In the present species, the last upper molar is proportionately narrower, and the intermediate lobes of all the upper molars are less developed. In other respects the teeth agree closely with those of the last species. The enamel of the upper molars is somewhat rugose, and there is a distinct basal ridge, except on the inner side.

*Measurements.*

| | |
|---|---|
| Antero-posterior diameter of last upper molar, | 12· mm. |
| Transverse diameter through anterior cones, | 10· |
| Transverse diameter through posterior cones, | 8· |
| Antero-posterior diameter of second upper molar, | 12· |
| Transverse diameter, in front, | 12· |
| Height of crown, | 6·5 |

The type specimen of this species was found in November, 1871, in the Miocene beds of Oregon, by Mr. F. Mead, Jr., of the Yale party.

*Eporeodon*, gen. nov.

Among the species now placed in the genus *Oreodon* of Leidy there are two well marked genera which may readily be distinguished by the base of the skull, and apparently by other char-

acters. In the form first described, of which *Oreodon Culbertsoni* Leidy may be considered the type, there is no indication of an auditory bulla, and for this group the name *Oreodon* may be retained. The other genus, which has a large auditory bulla, may be named *Eporeodon*. The type species is *Eporeodon occidentalis* = *Oreodon occidentalis* Marsh, from the Miocene of Oregon. The other known species of this genus are the following: *Eporeodon superbus*, = *Oreodon superbus* Leidy; *Eporeodon major*, = *Oreodon major* Leidy; and *Eporeodon bullatus*, = *Oreodon bullatus* Leidy. These species, so far as observed, occur in a somewhat different horizon of the Miocene, from the true *Oreodons*. They are, moreover, of larger size, and to this the proposed name refers.

*Agriochœrus pumilus*, sp. nov.

A number of specimens of a selenodont Artiodactyl, from the upper Eocene, agree so nearly with the known remains of *Agriochœrus* Leidy, that the species they represent may provisionally be placed in that genus. They indicate an animal less than one-half the size of the species already described. The teeth preserved agree in structure essentially with those of *A. latifrons* Leidy. The temporal fossæ were separated only by a sharp crest. Nothing has been known hitherto of the skeleton of this genus, but fortunately some of the more important bones were found with the teeth of the present species. These show that the feet are of the true Artiodactyl type, and somewhat resemble those of *Oreodon*. The tibia and fibula are distinct. The navicular and cuboid are separate. The metapodial bones are not united, and the second and fifth were present.

*Measurements.*

| | |
|---|---|
| Extent of last three lower molars, | 32· mm. |
| Antero-posterior diameter of penultimate lower molar, | 10· |
| Transverse diameter, | 8· |
| Transverse diameter of humerus at distal end, | 24· |
| Transverse diameter of articular face, | 17· |
| Least vertical diameter, | 11·5 |
| Transverse diameter at distal end, | 16· |
| Antero-posterior diameter, | 15· |
| Extent of three upper true molars (second specimen), | 32· |
| Antero-posterior diameter of first upper molar, | 9·5 |
| Transverse diameter, | 11· |
| Antero-posterior diameter of second upper molar, | 11· |
| Transverse diameter, | 13· |

The present species was about three-fourths the size of the Collared Peccary (*Dicotyles torquatus*). The specimens described are from the upper Eocene of Utah.

Yale College, New Haven, Feb. 20, 1875.

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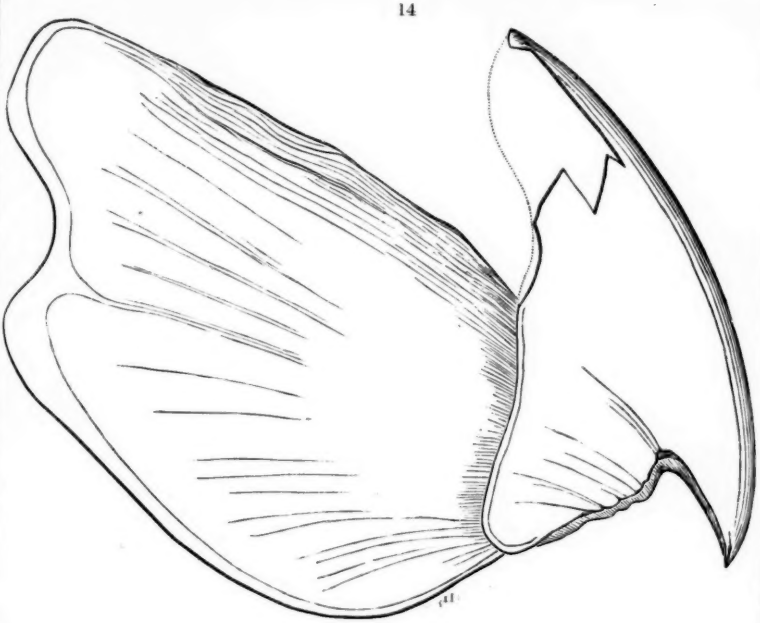

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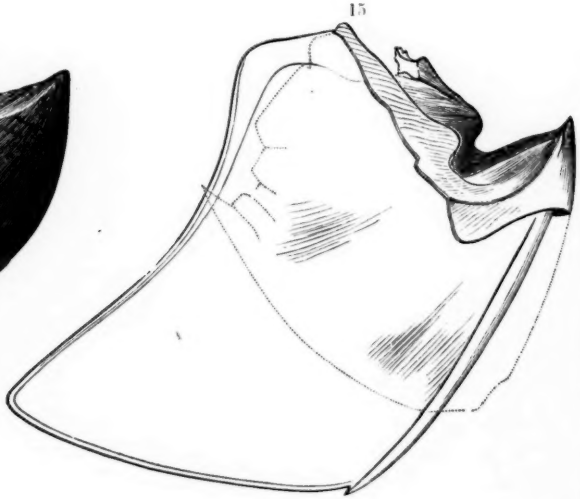

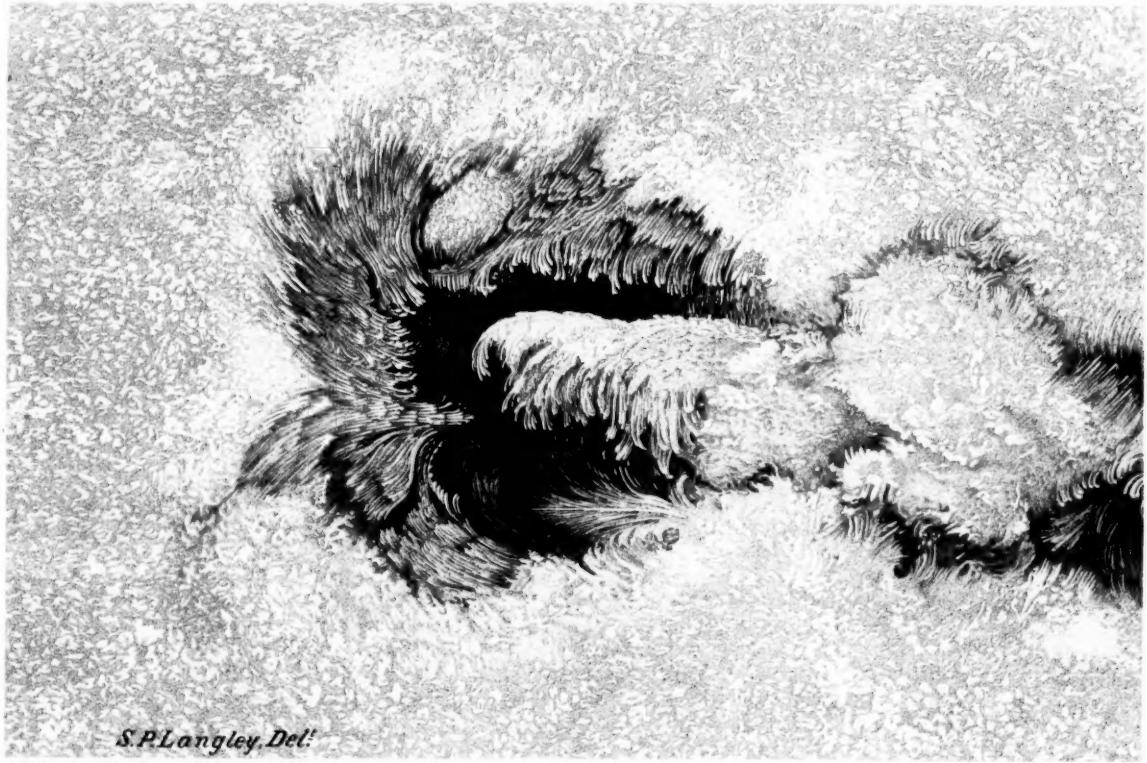


Allegheny Observatory. Jan 29. 24. 1873

Engraved by Samuel Sartain, Philad.ª

A TYPICAL SUN-SPOT